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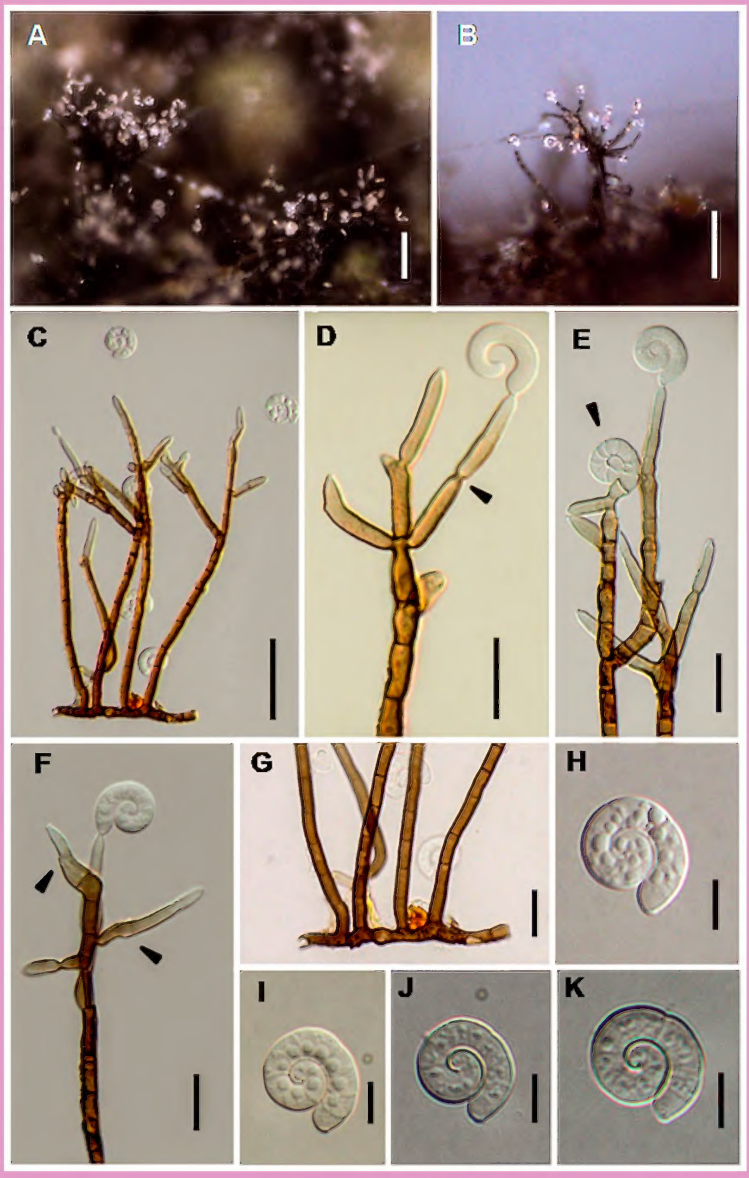

Helicoma barretoi sp. nov.

(Barreto, Carmo, Gusmão— PLATE. 1, p. 81)

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MYCOTAXON

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Reviewers — volume one hundred thirty-six (1)

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this issue.

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2021 Mycotaxon submission procedure

Prospective Mycotaxon authors should download the Mycotaxon 2021 guide, review & submission forms, and Mycotaxon sample manuscript by clicking the 'file download page' link on our Instructions to Authors page before preparing their manuscript. This page briefly summarizes our '4-step' submission process.

1—Peer review: Authors first contact peer reviewers (two for journal papers; three for mycobiota/fungae) before sending them formatted text & illustration files and the appropriate 2021 Mycotaxon journal or mycota reviewer comment form. Experts return revisions & comments to both the *Editor-in-Chief* <editor@mycotaxon.com> and authors. All co-authors must correct and *proof-read* their files before submitting them to the *Nomenclature Editor*.

2—Nomenclatural review: Authors email all **error-free** text & illustration files to the *Nomenclature Editor* <PennycookS@LandcareResearch.co.nz>. Place **first author surname** + **genus** + 'Mycotaxon' on the subject line, and (required) attach a completed submission form. The Nomenclature Editor will (i) immediately assign the accession number and (ii) after a few weeks return his notes and suggested revisions to the author(s) and *Editor-in-Chief*.

3—Final submission: All coauthors thoroughly revise and proof-read files to prepare error-free text and images ready for immediate publication. Poorly formatted copy will be rejected or returned for revision. E-mail the final manuscript to the *Editor-in-Chief* <editor@mycotaxon.com>, adding the **accession number** to the message and **all** files, which include a **(i)** revised 2021 submission form, all **(ii)** text files and **(iii)** jpg images, and **(iv)** FN, IF, or MB identifier verifications for each new name or typification. The *Editor-in-Chief* acknowledges submissions within two weeks of final submission but requests authors to wait at least 14 days before sending a follow-up query (without attachments).

4—Final editorial review & publication: The *Editor-in-Chief* conducts a final grammatical and scientific review and returns her editorial revisions to all expert reviewers and coauthors for final author approval. Author-approved files are placed in the publication queue.

The PDF proof and bibliographic & nomenclatural index entries are sent to all coauthors for final inspection. After PDF processing, the *Editor-in-Chief* corrects only PDF editorial/conversion and index entry errors; corrections of all other errors are listed in the Errata of a subsequent issue for no charge. Authors will pay fees for mycobiota uploads, optional open access, and correction of major author errors to the *Business Manager* <subscriptions@mycotaxon.com> at this time.

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From the Editor-in-Chief

Mycotaxon 136(1) contains 21 contributions by 80 authors (representing 15 countries) as revised by 35 expert reviewers and the editors.

Beginning with the 2021 January–March Mycotaxon, articles will henceforth be grouped according to section. This issue starts off with History and Ron Petersen's fascinating exposition on the introduction of the "new botany" to 19th century U.S. pedagogy and the influence of Professors Prentiss, Dudley, Thomas, and Whetzel upon the development of North American mycology and plant pathology.

The 11 titles under New taxa propose 4 new genera (*Blastophragmia, Distobactrodesmium, Teratospermopsis* from China and *Brykendrickia* from India) and 16 species new to science representing *Arthrinium, Blastophragmia, Camposporium, Craterellus, Endophragmiella,* and *Physalidiella* from China; *Brykendrickia* from India; *Helicoma* and *Scytinopogon* from Brazil; and *Smardaea* from Mexico. Three new combinations are proposed in *Distobactrodesmium, Endophragmiella,* and *Teratospermopsis.* New synonymies presents one paper that convincingly establishes *Pluteus luteus* as a synonym of *P. variabilicolor.*

New ranges and/or new hosts reports range extensions for species representing [hyphomycetes] *Dichotomophthora* for Iraq and *Endophragmiella* for China; [ascomycetes] *Spathularia* and *Trichoglossum* for Turkey; [basidiomycetes] *Clitocybula* for Argentina and *Gerronema* for Pakistan; and [myxomycetes] *Arcyria, Perichaena,* and *Physarum* (all also associated with a new substrate, acuri palm—*Attalea phalerata*) for Brazil's Pantanal region.

Our issue concludes with the announcement of one new annotated species list on our mycobiota website, which covers lichenized ascomycetes occurring on *Piptadenia moniliformis* and *Solanum mauritianum* in Brazil's Caatinga.

Mycotaxon 136(1) also provides keys to species in *Camposporium, Teratosperma, Smardaea, Scytinopogon, Physalidiella,* and *Blastophragmia*. Papers providing conclusions supported by sequence analyses include five new species representing *Arthrinium, Craterellus* and *Scytinopogon;* one synonymy, and two range extensions,

Mycotaxon 135(4) published in 2020 after all! Your *Editor-in-Chief* is delighted to announce that Mycotaxon Treasurer, Webmaster, & Owner factotum (Noni Korf) pulled a real rabbit out of the hat by hurtling the 2020 October–December issue (which she received the afternoon of December 29) through the publication maze so that Mycotaxon 135(4) was published in hard copy on December 30. Readers may not be aware that year-end issues present problems when released after December 31, because names published in a year not corresponding to the date on the cover must be cited with a double date in nomenclatural databases. It has been nine years since we escaped the double-date stigma, so we are especially pleased that 23 papers and 33 names are now dated "2020" and NOT "2021 ("2020")" as is usually the case.

Once notified that an issue is formally released (usually first in hard copy), we immediately upload this open-access cover section onto ResearchGate to announce publication. Subscribers and authors are invited to track journal progress by checking www.researchgate.net/project/The-Mycotaxon-Awareness-Project We now close issues fifteen days before the end of the quarter to grant your hapless *Editor-in-Chief* time to finish her scientific reviews before converting your manuscripts to gold.

The Mycotaxon Editorial Advisory Board welcomes Alfredo Justo—We announce with great pleasure the election of our new board member, Dr. Alfredo Justo, Curator of Botany and Mycology at the New Brunswick Museum (Musée du Nouveau-Brunswick), Canada. Dr. Justo, who is interested in the study of mycological biodiversity, including fungal systematics, phylogenetics, phylogenomics, biogeography, and conservation, also serves as an Associate Editor for Mycologia.

We thank profusely and bid farewell reluctantly to Brandon Matheny, who leaves the EAB after his extended seven-year term. "Fredo" joins Chair Else Vellinga, Past Chair Karen Hansen, and members Xinli Wei, Todd Osmundson, and Elaine Malosso on the Board.

Warm regards,
Lorelei Norvell (*Editor-in-Chief*)
31 March 2021

In Remembrance: Nancy Smith Weber (1943–2020)

Only a few are granted the luxury of being able to live—and work—their passion. Nancy Jane Smith was one such lucky person. It is, however, not surprising that the six-week-old baby girl who went on her first field expedition in the arms of her mother and who would later hang (in her mother's words) a "lovely bright red hand-knitted boot sock on her fireplace at Christmas time" (the "sole" survivor of a goodly supply knit expressly for her field-tramping father by a family friend) would evolve into Dr. Nancy Smith Weber, respected ascomycete expert adored for her work on *Morchella.* Nancy may have experienced the downside of field mycology at an early age—the endless succession of field seasons spent in wet, damp tents or drafty cabins with no bathtubs and kitchen tables covered with collections—but she also knew the joy that comes from finding an elusive mushroom in lush green forests while mastering a difficult science.

Nancy Smith Weber was born 12 March 1943 in Ann Arbor, Michigan, to North America's then foremost agaricologist, Dr. Alexander Hanchett Smith, and paleobotanist Dr. Helen Vandervort Smith. These two biological 'forces-of-nature' instilled a love of field and forest in their precocious child, who later shared her zest for fungi with all she met, including ranks of graduate students who knew less about mushrooms than she did. The three Smiths were close, and summers usually found Nancy with her parents on their western collecting expeditions or (in alternate years) at "Bug Camp" in Michigan.

After high school in Ann Arbor, Nancy attended Ohio Wesleyan University but after three years transferred to the University of Michigan, where she earned her AB (1965), MA (1967), and PhD (1971) degrees in Botany. In 1970, she married fellow student James A. Weber, and she and Jim lived in Ann Arbor where they co-edited The Michigan Botanist, Jim worked at the UM Biological Station, and Nancy conducted research at the University of Michigan Fungus Herbarium, also actively involved with the Matthaei Botanical Gardens (today the home of the Helen V. Smith Woodland Wildflower Garden honoring Nancy's mother). In 1989 Nancy, Jim, and the now-widowed Helen moved to Corvallis, Oregon, to Jim's new position with the US Environmental Protection Agency Lab and Nancy's appointment as Assistant Professor/Researcher at the Oregon State University Department of Forest Science. During 1995–2004 she was also contracted as ascomycete identifier for the Northwest Forest Plan and ranked rare and unusual

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The Field-Tripping Smith Family in 1970

fungi for the Oregon Natural Heritage Information Center—encountering in the process the frustrations inherent in 'government work.' After Jim's unexpected death in 1998, Nancy began a fungal survey of her now-famous backyard, expanding her knowledge of kingdom *Fungi* and reaffirming her belief that fungal "rarity" is probably more related to the scarcity of mycologists than to the real presence of species in a landscape. Nancy, who became well known as "the Mushroom Lady of Corvallis," died of complications from Parkinson's disease on December 19, 2020.

Dr. Weber published over 40 scientific papers and wrote or coauthored five highly popular field guides—How to Know the Gilled Mushrooms (Smith, Smith & Weber 1979), the revised The Mushroom Hunter's Field Guide (Smith & Weber 1980), How to Know the Non-Gilled Mushrooms (Smith, Smith & Weber 1981), A Field Guide to Southern Mushrooms (Weber & A.H. Smith 1985), and A Morel Hunter's Companion (Weber 1988). She was also major force in the successful publication of Hesler & Smith's North American Species of *Lactarius,* and expended considerable effort in developing Pezweb (with its preliminary checklist of the *Pezizales* of western North America), only to be disappointed when the website lost its government platform sometime after 2001.

Perhaps Nancy's greatest contribution was her active participation in mycological and botanical societies. A life member of the Mycological Society of America (MSA) and North American Mycological Association (NAMA), she was in 2007 awarded the prestigious NAMA Award for Contributions to Amateur Mycology for her more than 30 years of devoted service to amateur mycology. Dr. Weber was a member of numerous other scientific societies, where she delivered over 95 lectures. Five species have been named in her honor: *Boletus nancyae, Brauniellula nancyae, Galerina nancyae, Lactarius nancyae*, and *Russula nancyweberae.*

I don't remember the exact year when I first met Nancy at a NAMA meeting in the 80's, but we encountered each other frequently after she moved to Oregon. We became friends in 1995 as we 'herbarium' hopped together from Oregon to San Francisco (SFSU) and Ann Arbor (MICH) where we prowled the fungaria for collections of the

Linnea Gillman, courtesy of Mike Beug

Steve Trudell

Left: Father & Daughter at the 1983 NAMA Foray, Granby Colorado
Right: The morel expert, truffling at the 1992 Oregon Mycological Foray

Left: Herald Treibs, Gene Butler, Nancy, Buck McAdoo at PNW Key Council, 1989 (UW Seattle)
Right: Vera Evenson & Nancy puzzle over a *Hebeloma* at the Denver Botanic Garden, 1995

Northwest Forest Plan's species of concern. Definitely in her element in Ann Arbor. she made certain to introduce "Joe Ammirati's student" to one and all while we were there. Having joined the Oregon Mycological Society, she became part of the group I alternatively called the OMycoBelles (OMSers) or the LOLs—Little Old Ladies, all born between 1943 (Nancy, I, Judy Roger) and 1933 (Janet Lindgren in 1934, Maggie Roger in 1933)—who met for the first time in 2003 under that appellation in Yamhill to celebrate my 60th. A gracious hostess whenever we stayed in Corvallis for meetings, she was also brilliant, hardworking, and an amusing lecturer who treated tedium with sardonic wit. After a particular difficult 2½ sleepless weeks when we attempted to rank rarity for 70 species in the absence of data for a bureau that nonetheless insisted we format our references in a particular form known only to it, a frustrated Nancy dispatched an Email to the powers that be, noting "Here is the way I usually do articles: Do, R.E., Me, F. A. 2002. Macrofungi and lichens of Portland's parking lots. Journal of ridiculous research. 5: 16-23." thereby inheriting a new title. We all most definitely miss our terrific Editor of the Journal of Ridiculous Research. *—Lorelei Norvell*

LOLs at the Joel Palmer House, 10 September 2003
(Janet Lindgren, Lorelei Norvell, Maggie Rogers, Nancy Weber, Judy Roger)

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Four master teachers who fostered American turn-of-the-(20TH)-century mycology and plant pathology

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Abstract—The Morrill Act of 1862 afforded the US states the opportunity to found state colleges with agriculture as part of their mission—the so-called "land-grant colleges." The Hatch Act of 1887 gave the same opportunity for agricultural experiment stations as functions of the land-grant colleges, and the "third Morrill Act" (the Smith-Lever Act) of 1914 added an extension dimension to the experiment stations. Overall, the end of the 19th century and the first quarter of the 20th was a time for growing appreciation for, and growth of institutional education in the natural sciences, especially botany and its specialties, mycology, and phytopathology. This paper outlines a particular genealogy of mycologists and plant pathologists representative of this era. Professor Albert Nelson Prentiss, first of Michigan State then of Cornell, Professor William Russel Dudley of Cornell and Stanford, Professor Mason Blanchard Thomas of Wabash College, and Professor Herbert Hice Whetzel of Cornell Plant Pathology were major players in the scenario. The supporting cast, the students selected, trained, and guided by these men, was legion, a few of whom are briefly traced here.

Key words—"New Botany," European influence, agrarian roots

Chapter 1. Introduction

When Dr. Lexemual R. Hesler died in 1979, he left a manuscript entitled "Biographical sketches of deceased North American mycologists, including a few European mycologists" (Hesler 1975). These 147 "thumb-nail" biographies, ranging from a half-page to five pages, included almost no plant pathologists, even though Hesler was one for the first half of his career. Moreover, Hesler was

a proud product of Wabash College (class of 1911) and extolled the role of Prof. Mason Thomas in his life. Second, I spent a single pivotal semester (Fall 1956) in the Cornell Plant Pathology Department and retained some appreciation of scientists associated with that department. Third, Hesler had alluded to intradepartmental strife at Cornell which led to his migration to the University of Tennessee. Later, I came upon the paper by G.C. Kent (1979), long-time head of the Cornell Plant Pathology Department, who summarized Prof. Thomas's role in guiding selected Wabash students into graduate education leading to successful careers. Finally, the paper by R.P. Korf (1991), a Cornellian as undergraduate, Ph.D. student, and career faculty member, referred both to Prof. Thomas and to the Cornell disturbance. As added background, the influence of post-Civil War but pre-World War I events on the maturation of mycology in North America has already been published (Petersen 2019).

In addition to the Hesler heritage, some historical topics should be considered. First, the summer of 1862 was a season of government turmoil. As the Civil War spread and raged, the congressmen representing the States of the Confederacy walked out of the federal congress, ceding control to the Union states. In the midst of a war, the federal government was not only short on cash, but through expansion and the Louisiana Purchase, found itself owner of almost limitless land west of the Mississippi River. Respectful of its critical role in the War effort, the government was moved to expand its role in agriculture. It was also calculated that if land grant legislation were passed, perhaps some hearts in the south would be persuaded that rebellion was too costly. Two bills were put forward in 1862 to respond to these schemes as well as to some popular agitation that had been simmering for years.

There was already a history of bounty-land warrants, especially to recognize veterans of military service from the American Revolution forward. But in a few days during the War Between the States, new laws were enacted. On 15 May 1862, Congress established the Department of Agriculture and five days later, on 20 May, the Homestead Act was signed into law. It guaranteed 126 acres of federal land to any person willing to settle on and cultivate it. The law answered a movement for free ownership of otherwise unsettled land. In brief, this was the first "land-grant" act of the age. Within days (July 2) the Morrill Act was signed, gifting, upon application, each state a grant of federally owned land upon which to found a college at which agriculture was a significant part of the educational program.

Second, by the decade (the 1880s) in which most students covered in this narrative were born, relations were strained between the Euro-American

settlers—in their incessant western movement—and the Amerindians, whose land, hunting territory, and economic bases were being usurped. The military confrontations had largely subsided, but establishment of reservations and relegation of Amerindians to new lands (and therefore modes of survival) were well underway. Much of this escaped the headlines "back east," but west of the Mississippi River these interethnic adjustments were big news. As the issues extended into the early and middle 20th century, "western territories" applied for statehood, the Morrill Act was ratified, states filed applications, land grants were assigned, land-grant colleges were established, and agriculture expanded as both academic discipline and lifestyle. The Hatch Act of 1887 repeated the process, this time mandating that agricultural experiment stations be associated with the land-grant institutions. Concurrently, plant pathology was increasingly recognized as a positive adjunct to the farmer. After all, at the turn of the 20th century, 50% of all Americans made their living by farming. Finally in 1914 just prior to World War I, the "third Morrill Act" (the Smith-Lever Act) brought laboratory research into the hands of the farmers themselves.

Science itself was evolving during this period, and the general focus on agriculture and the land grant movement spawned the development of laboratory and experimental approaches in both research and teaching. Although this narrative is directed at a particular network of teachers, their students and the growth of mycology and plant pathology in the United States, this tableau paralleled changes in natural science pedagogy, especially because some of the teacher-innovators were also actors in the main plot. Several individuals presented here studied in Europe with scientific innovators. They brought back to the US not only techniques but also a keen ambition to place botany and its sub-sciences at the forefront of academic studies. Central to the education of several scientists was the "New Botany" as espoused by Charles E. Bessey, early educator in botanical sciences, and several other professors. This pedagogical progress has been summarized by Sundberg (2011, 2012, 2014).

The starring players in the current report are four in number: Prof. Albert Nelson Prentiss, on faculty at the precursor of Michigan State University, who moved to the fledgling Cornell University upon its opening in 1868; Prof. William Russel Dudley, student at Cornell during the Prentiss years and thereafter a faculty member with Prentiss; Prof. Mason Blanchard Thomas, a fellow student with Dudley, but who moved to Wabash College; and Prof. Herbert Hice Whetzel, student at Wabash and Cornell, later Head of the Cornell Plant Pathology Department. The supporting cast, the students of these professors, was legion, of which some have been selected here for lesser roles.

Chapter 2. Albert Nelson Prentiss (22 May 1836–14 August 1896)

In 1835, upstate New York was decidedly rural. Somewhat south of Syracuse and Utica, Cazenovia (in Madison County) was a hamlet at the south end of Cazenovia Lake, easternmost of the Finger Lakes. Albert Nelson Prentiss (Fig. 1) was born on a farm there, and after the local schools attended the Oneida Conference Seminary, a private school supported by the Methodist Church but educationally nonsectarian and a pioneer in co-education. Among its more famous graduates were Jesse Truesdell Peck, first president of Syracuse College and Leland Stanford, Jr., founder and endower of the eponymic California college.

The teachers and processes identifying Prentiss as a promising student have been lost, but his family must have supported his enrollment at the Seminary socially and financially, followed by his choosing the Agricultural College of the State of Michigan to further his education. In 1858, some four years before the Morrill Act was enacted into law and at age 23, he enrolled.

For many years before the Civil War there were murmurings aimed at establishing colleges supported by government, either state or federal. In fact, Justin Smith Morrill proposed his bill in the 1850s, but it failed repeatedly. In four years, Michigan took things into its own hands and established the Agricultural College of the State of Michigan. For young Prentiss, it was one of only a very few from which to choose. Over the years its name would be changed to Michigan State College of Agriculture and Mechanics, and finally, in 1964, to Michigan State University.

The Morrill Act (finally passed in 1862) stimulated a surge in college establishment. From 1860 to 1870, 175 new colleges were founded, and "respectable" colleges had at least four science faculty members (Rudolph 1977). In the spirit of the classical education which still dominated college and university curricula, book-reading, recitation, and professorial questions and student answers were the chief means of learning.

The Civil War had begun to rage when Prentiss was awarded a B.S. in 1861. Patriotism for the Union cause was fervent. Of the graduating class of seven, all immediately enlisted in the army.

The timing of his enlistment was delicate. Prentiss was assigned to special signal service in Missouri, but after a few months his unit was dismissed. A major reorganization of the army was taking place in the wake of the dismissal of the commanding general, George T. McClellan. McClellan had been promoted to General-in-Chief of the Union Army, but he and Abraham Lincoln, the new President, distrusted one another and McClellan was the loser. His term as

Fig. 1. Albert Nelson Prentiss. Atkinson GF 1896 Botanical Gazette 21: 283–289.

General-in-Chief, November 1861, to March 1862, coincided with Prentiss's enlistment. Prentiss was sent home to Cazenovia.

Possibly through contacts made at Michigan State, Prentiss spent the academic year 1862–63 as associate principal of Kalamazoo High School,

Michigan, not far from his alma mater. By the fall of 1863, he was listed on the faculty of Michigan State Department of Horticulture. Concurrent with his official duties, he earned an M.S. in 1864, and in 1865 he became Professor of Horticulture and Botany as well as Director of Grounds.

Albert Prentiss had been raised in an agrarian lifestyle, left home, been a college student, survived boot camp, and now, at 32, put all these to practice as a professor—and director of grounds. His total time on faculty was to be five years.

For some notable students of Prentiss at Michigan State University, see Appendix 1. One, Charles Edwin Bessey, progressed into a pivotal career as an innovator of botanical pedagogy.

In the early third of the nineteenth century the de facto controversy for botany was the "Linnaean System" versus the "Natural System." The former used a formulaic system locating and numbering flower parts to arrive at the name assigned to the plant in question. The "Natural System" relied on more information—habit, ecology, physiology, anatomy, etc.—in order to place plants in "natural" groups (Sundberg 2011). The chief disciples were Amos Eaton (Linnaean System) and Asa Gray (Natural System), but the modes of teaching were consistent.

Compared to the reading–recitation–lecture-centric teaching of botany in mid-19th century America, quite a different approach was developing on the European continent, particularly in Germany. As early as 1849, the second edition of Schleiden's botanical textbook, which strongly emphasized cellular and anatomical studies, was translated into English. In the early 1860s, Hofmeister published his 4-volume work *Handbuch der Physiologische Botanik*, soon considered one of two game-changers in biological thinking. The other was Darwin's *On the Origin of Species* (Green 1967).

At Harvard, William Gilson Farlow was a student in botany. Upon graduation and on the advice of Prof. Asa Gray, Farlow enrolled in the medical school and in 1872 was awarded his M.D. Again with advice from Gray, Farlow embarked for Europe for what became a two-year absence. As well as studying with Anton de Bary in Strasbourg and using some of his family wealth to purchase books and herbaria, Farlow observed that European botany students were better prepared than those in the United States for entering into hands-on learning. Part of this was the early introduction of botany in preparatory school curricula as well as the wide use of living plants and laboratory observation where students could participate with the teacher in the subjects covered in lectures. In short, in the classroom, students and teachers were partners.

In 1866, Charles Bessey (see APPENDIX 1), who entered Michigan Agricultural University intending to become an engineer, also took courses in botany from Prof. Prentiss. The sole botany classroom contained a large glass cabinet housing the "Ross compound microscope." Bessey later related the story of his epiphany in pedagogy. "It was never taken out for use in class, but always stood there as a challenge to us. I do not know what anyone else did, but at last I could stand it no longer, and getting permission from Professor Prentiss, who gave me the key to the case, I locked myself in the classroom, and taking out the ponderous instrument, looked it over, studied its complex machinery, and made myself familiar with its structure and use" (Bessey 1913). Bessey completed his B.S. degree in November 1869 and began his first faculty position the next month at Iowa Agricultural College in Ames. Following his Michigan experience, he started bringing simple experiments into the lab, most centering on histological manipulation and use of a microscope. He soon became an evangelist for a new teaching philosophy for botany.

Meanwhile, in Ithaca, New York, conversations were taking place concerning the possible founding of a college. Several well-placed men were involved, of whom one was Ezra Cornell.

Two members of the state senate, Andrew Dickson White (1832–1918) of Syracuse and Ezra Cornell (1807–74) of Ithaca, emerged from different generations and backgrounds but shared an interest in establishing a college in New York State. Cornell, a journeyman carpenter by trade but by this time in late middle-age, had made a respectable fortune in the telegraph industry and owned an estate and model farm in Ithaca. White was a son of a wealthy banking family. Educated at Yale and part of "the famous class of 1853," he had travelled widely in Europe and had been a professor of English and history at the University of Michigan (not Michigan State). Cornell's offer to deed his farm to a college established in Ithaca and to contribute $500,000 to the cause furnished a target location. In 1862, the Morrill Act afforded an opportunity to see their concept come to life on behalf of New York State.

The impecunious federal government could not award monetary funds to back the terms of the Morrill Act and allotments to the states was by scrip, a promissory note for federally owned land. Each land grant was in proportion to the number of representatives (and therefore, the population) of each state. Under the canny influence of Cornell, New York chose 989,920 acres of timberland in western Wisconsin Territory (the eastern portion had become a state in 1848), with a value of about $2.5 million in mid-19th century funds.

The land grant, together with the munificent Cornell monetary donation and Cornell's farm were enough to fund a modest college.

Cornell University was founded on 27 April 1865. After spirited debate the university was named for its benefactor, and its first president was Andrew Dickson White. But merely to pronounce the existence of a college did not magically produce staff, buildings, or curriculum—much less students and income.

Now the difficult tasks commenced. During the next three years, White saw to the construction of the first two buildings and travelled to recruit students and faculty. It was planned that the University should start with 26 professors split between resident and non-resident faculty. The non-resident faculty would be famous personages in their respective fields, and their recommendations would be influential in recruiting the resident faculty and advertising the college. One such non-resident was Louis Agassiz, the celebrated natural science magnate at Harvard. Between Agassiz and White, an offer was made to Albert Prentiss of Michigan State, who was approved at the eighth meeting of the trustees on the very day of the university's opening, 6 October 1868. Prentiss was already in Ithaca, ready to assume the position of Chair of Botany, Agriculture and Horticulture and Director of Buildings and Grounds. The following day, 412 male students were enrolled, just a few months after Andrew Johnson, President of the United States, had been impeached.

The contrast between bucolic Ithaca and urbane New York City was stark. New York City, for example grew from 500,000 in about 1825 to just less than a million by 1870. Growing pains also increased. It was said that a lady in lower Manhattan could wait a half-hour to cross the street, so crowded was the traffic. The first elevated railway was opened on 2 July 1868, running between the Battery and Cortlandt Street, just some two months before Cornell opened its doors. With steam propulsion, the trains moved between five and 10 miles per hour. The system was extended, but its pollution and noise were oppressive and calls for some other system became politically exigent.

According to Atkinson (1896 a,b) Prentiss's course in General Botany opened with four students, but the following year enrollment was 144. For three years, physical space was "borrowed" from chemistry. Over the years the students in Prentiss's classes, through his influence, became interested in the local flora; students included David S. Jordan (later President of Leland Stanford Jr. University in California), J.C. Branner (later Ph.D. botanist) and William R. Dudley (later professor at Cornell and then Stanford). The first

careful flora of the region was compiled by Prentiss and published by Dudley after Prentiss's death.

Just as had been the case at Michigan State, the job of overseeing buildings and grounds took inordinate time. In a memorial article years later upon Prentiss's death, the Cornell Daily Sun (Anonymous 1896) wrote: "He showed great enthusiasm in organizing the work under the very adverse conditions which prevailed for the time and for several years. He planned early for beautifying the campus by planting seeds in the fall of 1868, of a number of kinds of trees for a nursery. Many trees from the nursery were planted over the campus, but nearly all have been destroyed by subsequent grading for new buildings."

Prentiss met his classes and researched the flora of the surrounding countryside but in 1870, he accompanied Prof. C.F. Hartt on an expedition to Brazil (organized by Hartt but henceforth known as the "Morgan Expedition" after its chief underwriter). With a number of students, they pushed off from New York in late June, returning early in January 1871. The party made collections in natural history and studied the natural resources of the country along the course of the Amazon to about 400 miles above Pará, as well as along the rivers Chingu and Tapajos, two of the principal tributaries of the Amazon. There was time enough to see Rio de Janeiro. Drawing on this trip into the tropics, Prentiss wrote an essay in 1871, "Mode of the natural distribution of plants over the surface of the earth," which won the first Walker prize offered (and published) by the Boston Society of Natural History. But in contrast, he also wrote an extended monograph of the hemlock (*Tsuga* spp.) for the United States Department of Agriculture (USDA) Division of Forestry. That same year the Chicago Fire (with almost one third of the city consumed) dominated headlines.

In these years, American academics were coming to appreciate the breakthroughs produced in European laboratories. It became relatively common, although expensive, to travel to Europe to work with a leading researcher and to visit the premier institutions in the capitals. Prentiss spent six months in 1872, visiting the Royal Botanic Garden at Kew, the Jardin des Plantes in Paris, and several other important botanic gardens. His facility with French was helpful. In a matter of three years he had experienced the biota, ecology, and peoples of the American tropics as well as the sophistication of European science and lifestyle, both a long way from Cazenovia, New York.

As if the Chicago Fire wasn't sensational enough, the 1872 Boston Fire seemed apocalyptic. Completely separate, though, when Prentiss returned to

upstate New York, Cornell, too, was a remarkably different place than the one he had left. Economic collapse was on the horizon.

The Civil War had been followed by a boom in railroad construction. Like the canal craze of a previous half-century, development of railroads had exploded. Between 1868 and 1872, 33,000 miles of new track were laid across the country. Much of the railroad investment craze was driven by government land grants and subsidies, this time to the railroad corporations. The railroad industry, including its manufacturing and shipping support, was the nation's largest employer outside of agriculture, and involved generous amounts of money and risk, especially bartered in the money markets of the northeast. The result was over-development of those very supporting factories, warehouses, and other ancillary facilities. A large infusion of cash from speculators caused even more abnormal growth. In modern parlance, a bloated "bubble" burst in "the panic of 1873." To be sure, the panic followed a series of economic scares including removal of silver as a denomination of coinage. The result was catastrophic: unemployment became acute and banks failed, creating a general economic crisis, with colleges and universities particularly threatened.

Cornell was not exempt. Student enrollment decreased. Faculty salaries came under attack. Teaching loads increased while research was expendable. The "Great Depression of 1873–77" cast a pall over campus.

As though bringing the mountain to Mohammed, in 1872 the AAAS met in Dubuque, Iowa, where Charles Bessey met Asa Gray, the presiding President. They arranged for Bessey to spend his 3-month winter break at Harvard, where in addition to Gray, he would also work with George Goodale, a physiologist, and study fungi and systematic botany. The following semester, back in Ames, he moved a table, one microscope, and a few reagent jars into a small room at the end of a corridor with a sign over the door—"Botanical Laboratory." Bessey claimed that this was the "First botanical laboratory outside of Harvard" (Sundberg 2012). (1872 also saw Susan B. Anthony, a Quaker, jailed for protesting for women's suffrage.)

At Iowa State, unlike eastern universities, a significant amount of the curriculum was science, with a full year of botany required in the sophomore year (Beal 1908). Bessey later recalled that "with the possible exception of Harvard, this college [Iowa State] then gave the most extended and thorough course in botany in this country" (Bessey 1913). The first term of the junior year was split between vegetable physiology, economic botany, and cryptogamic botany—all making use of the herbarium and college microscopes (Pool 1934–35). Within two years, seven compound microscopes were provided.

Four years afterward, in 1880, there were 11 compound scopes in a new building with a large botanical laboratory on the first floor. Still three years later, the lab had 21 student compound microscopes and a "first class microscope, with accessory apparatus, and high-power objectives" (Pool 1934–35). Bessey later took pride in recalling that the administration and his faculty colleagues believed "that the professor of botany was slightly 'queered' or out of his head when the subject of microscopes was under discussion" (Sundberg 2012).

The laboratory as part of instruction became Bessey's trademark. While a visiting professor at the University of California in 1874–75, he introduced botany students to the laboratory method, doing the same during a visit to Minnesota in 1881, where he offered a summer school botany course for teachers (Bessey 1881). By 1885, a dozen colleges had botanical laboratories equipped with microscopes for student use (Arthur 1885).

Asa Gray had inaugurated a summer course for teachers and others in 1872 (Pfister 2010), and now, in 1874, Farlow returned from Europe with ideas about hands-on teaching. Later in October that same year, the star of the Exposition Universelle in Paris, Gustave Eiffel's Tower, was the wonder of the world. It was also the year that George Goodale offered a winter course for teachers on how to teach botany (Goodale 1879; Bessey 1880a). The course intended to teach teachers how to stimulate students to learn for themselves. This was accomplished by using interesting and attractive living plants, asking leading questions to guide the student's inquiry, and answering only questions that the student could not answer for him(her)self with direct observation.

In 1878, Albert Prentiss married Adaline Eldred. The couple had no children, so Adaline was able to accompany Albert in many of his travels. During the ensuing years, teaching continued and departmental and physical plant administration consumed inordinate time while new students arrived, some of whom were encouraged in their botanical studies.

In Iowa, Bessey's new textbook, *Botany for High Schools and Colleges* (Bessey 1880a), was one of the first emphasizing "the new botany" in America, a term coined by Beal (1879) at Michigan Agricultural College, but soon taken up by other, mostly younger, midwestern botanists including Bessey, J.C. Arthur (Bessey's undergraduate and Master's student), and their mutual friend John M. Coulter at Wabash College. The book sold out within six months and went through a large reprinted edition. Pressed by his publisher for a book aimed at even younger children, Bessey (1884) published *The Essentials of Botany.* Both books were lavishly illustrated.

Back at Harvard, Goodale (1879), the physiologist, published a paper to aid in teaching botany. The paper covered a few common plants. Shortly thereafter, J.C. Arthur (1880) published the first teaching paper in an American botanical journal, suggesting that pumpkin was a most useful example of a dicot stem to use in the laboratory classroom. Two years later, Bessey suggested that asparagus stem was an optimal monocot for teaching (Bessey 1882), and Arthur (1885) further endorsed the laboratory experience as well.

As might be expected, at Cornell Prentiss oversaw the botanical training of some notable students bound for greater lives (Appendix 2). In 1874, William Russel Dudley (see Chapter 3) was awarded his bachelor's degree. Finding employment loomed as a major problem but Dudley had already assisted Prentiss in the introductory course because much of Prentiss's time was taken up with campus construction and beautification. Dudley remained in the botany department as an instructor, relieving Prentiss of the introductory courses until leaving Cornell in 1893 for a professorship at Leland Stanford Jr. University in California.

George Francis Atkinson was another student of the Prentiss era. Originally from rural Michigan, Atkinson transferred to Cornell as an undergraduate in about 1883. His botanical education was probably shared by Prentiss and Dudley. At any rate, Atkinson was awarded his B.Phil. in 1885. As Dudley before him, Atkinson was made an assistant to Prentiss. After graduation he pushed off from Cornell for some years on faculty at some southern schools (see Petersen 2019, p.71), only to return thereafter.

How William Ashbrook Kellerman from Ohio came to entertain ideas of college is unknown, but the funds for matriculation at Cornell were found and he probably entered in 1870, for he graduated in 1874, only six years after the establishment of the University. Prentiss was away in the Amazon and again in Europe for three of Kellerman's Cornell years. Nonetheless, Prentiss was department head, and Kellerman was likely to have had classes with him. Chances are better that he rubbed shoulders with fellow student William Dudley. Kellerman was to embark on a celebrated career in Kansas followed by Ohio (and death by malaria during fieldwork in Guatemala).

Mason Blanchard Thomas, a young man from New Woodstock, New York, came to Cornell in 1886, graduated with a B.S. in 1890, and remained for graduate studies. In 1891, however, he accepted an appointment as professor at Wabash College in Crawfordsville, Indiana (see Chapter 4).

In November of 1884, Bessey left Iowa State University to become Professor of Botany and Horticulture and Dean of the Industrial College at the University

of Nebraska. He vowed that the program at Nebraska would not "still regard botany as a pleasant pastime consisting mainly of flower hunting..." or where "the scientific botanist was one who collected, dried, and pressed into dead flatness the plants of his neighborhood, only to attach to them afterword [sic] certain Latin names...." (Bessey 1885; Sundberg 2012).

In 1886, Gustave Eiffel again came to the attention of Americans. Although Frédéric Bartholdi sculpted the Statue of Liberty, it was Eiffel who designed its steel framework. The statue was paid for by French people and positioned on Bedloe's Island on a pedestal financed by Americans. Dedicated in October in New York Harbor, it was celebrated by the first tickertape parade up Fifth Avenue.

Atkinson (1896a): "During the later years, failing health, while it did not prevent [Prentiss] from attendance upon the duties of instruction and administration of his office, did not leave him sufficient reserve strength for the close and continued application necessary in conducting extended experiments or prolonged research."

In 1896, Prentiss died at 60 years old. At Cornell's Sage Chapel there is a plaque that reads "In memory of Albert Nelson Prentiss M.S. First Professor of Botany at Cornell University 1868-1896. Born May 22, 1836. Died August 14, 1896. A noble man, a devoted scientist, a faithful teacher." A note in the Cornell Sun read: "While Professor Prentiss never manifested any great enthusiasm himself, he could arouse more enthusiasm in a student, and get more work out of him, than any man I ever knew."

A piece in Gardening Magazine reported: "At Prentiss's death (1896) the Cornell botany department had the following personnel: Geo F. Atkinson, Ph.D. [sic] professor of botany; W.W. Rowlee, B.L., D.Sci, assistant professor of botany; E.J. Durand, A.B., D.Sci., instructor in botany; K.M. Wiegand, B.Sci., assistant in botany; B.M. Duggar, A.B., A.M., assistant in charge of experiment station botany; Robert Shaw, head gardener, in charge of conservatories, W.A. Murrill, B.Sc., Virginia Agr. College, scholar in botany." Twenty-eight years previously, Prentiss had arrived as a department of one.

Chapter 3. William Russel Dudley (1 March 1841–4 June 1911)

Guilford, Connecticut, on Long Island Sound some miles east of New Haven, was home territory for the Dudley family since colonial times. William Russel Dudley (Fig. 2) was born and raised on a family farm, and reports from later

years indicate that the family might have been landed but was not aristocratic. His early schooling has not been uncovered but he took interest in nature, especially the flowering plants that surrounded him. Although other colleges were considered, he chose Cornell for its emphasis on science. He arrived there in 1870 (age 29), sought out the botany department, and there made friends with fellow student David Starr Jordan, Assistant to Professor Prentiss. Many years later Jordan would describe his new friend as: "a tall, well-built, handsome and refined young man, older and more mature than most freshmen, and with more serious and definite purposes" (Anonymous 1913). Immediately, Dudley set out to explore his new environment, including collecting fungi (Cooke 1956). As it turned out, he and Jordan roomed together for the following years and soon made joint field trips.

Dudley paid his way at Cornell by milking cows at the university farm. He and Jordan roomed in a small cabin near the small campus and soon a small cadre of aspiring botanists gathered, some destined to become notable academics in their own right.

In 1870, just as Dudley arrived at Cornell, construction began in New York City on a bridge between suburban Brooklyn to business-centric Manhattan. It was called the New York Brooklyn Bridge, but the name would be shortened to The Brooklyn Bridge.

Although words of eulogy may be discounted by circumstances, even in his youth Dudley was consistently described by preciseness, purity of thought and intention (particularly in the last decades at Stanford), but as stated by Jared Treman Newman (Anonymous 1913): "Of fine New England stock, cultured, with a refinement that was genuine all the way thorough, doing splendid work in his chosen profession and capable of making a great name for himself, his best service to the world was in imparting to other men higher aspirations and nobler ideals."

Dudley impressed his new friend Jordan by his attitude and growing knowledge and, when Jordan moved on, Dudley was selected in his sophomore year as Jordan's replacement as Assistant to Prof. Prentiss. He served in that capacity for Prentiss's course in fungi for four years, qualifying him to be listed as a mycologist many years later.

Graduating in 1874 with a B.A., Dudley stayed on, enrolling for graduate studies. In 1875, he spent the summer on Penikese Island, a tiny plot off the south coast of Massachusetts, taking a field course from Louis Agassiz, Harvard University's famous zoologist. This was the first American field course located in the midst of the material to be studied and was an early model for the Marine

Fig. 2. William Russel Dudley. Dudley Memorial Volume, Stanford University. 1913.

Biological Laboratory at Woods Hole, Massachusetts, founded in 1888. Dudley returned to the island in 1876, just after receiving an M.A. from Cornell and a

promotion to Assistant Professor of Botany. The island was to become a leper colony in the 20th century. In 1878–79 Dudley served as Professor of Botany at the Martha's Vineyard Summer Institute.

A year later, his old roommate, David Jordan, by now President of the University of Indiana, was scheduled for a leave and asked Dudley to substitute for his teaching responsibilities. Dudley complied, taking leave from Cornell. But Jordan was not finished with him. John Casper Branner (Anonymous 1913) related: "When Dr. Jordan was President of the University of Indiana, he tried for some time to induce Dudley to go to that institution as professor of botany. And I recall in this connection that Dr. Jordan said to me on one occasion: 'Quite aside from his ability as a teacher of botany we need him here on account of his personal influence.' But Dudley declined the proffered position largely because he felt that he was not altogether fitted for the pioneer work required there at that time."

As if to express American exceptionalism, John A. Roebling's masterpiece, the Brooklyn Bridge, was opened for traffic on 24 May 1883, far away from the rural areas producing the academic centers of this narrative. As a reminder, popular, affordable internal-combustion automobiles were still 30 years in the future. Some lives would be lost in its construction, but the bridge was to stand as a monument for over a century and still acts as a prime artery, now by vehicle and foot traffic. It was a structure to be admired (and scams still offer it for sale). That same year, Dudley was again promoted, this time to Assistant Professor of Cryptogamic Botany, reflecting his experience teaching the mycology course.

In 1886, he went out of character, publishing three biographical sketches of mycologists in *Journal of Mycology*, edited by his Cornell student friend William Ashbrook Kellerman: "A sketch of [Moses Ashley] Curtis;" "Elias Magnus Fries;" and "Charles Christopher Frost." These sketches had been advertised by Kellerman at the end of volume 1. As the years passed, Dudley remained at Cornell, now on the faculty of a growing department. In 1887, like Prentiss before him, Dudley travelled to Strasbourg in Europe to work with Anton de Bary, who was experimenting with plant and fungus physiology. When de Bary died the following year, Dudley wrote a eulogy in Botanical Gazette.

1888 was a year of change for Cornell's botany department. Liberty Hyde Bailey, Asa Gray's last student and a horticulturalist intent upon taking botanical—largely agricultural—knowledge from the lecture hall and academic laboratory to the practicing public engaged in agricultural pursuits, entered the botany department through Cornell's Agricultural Experiment

Station in Geneva, New York. While Bailey's vigor enlivened the personnel, it also roiled the routine of teaching and research. 1888 was also noted for the death of Asa Gray.

David Jordan moved again, this time as President of the brand-new Leland Stanford Jr. University (later shortened to Stanford) in Los Altos, California. He renewed his effort to bring Dudley on board, and this time Dudley was listening. Dudley's last paper written at Cornell, "Flora of the Lackawanna and Wyoming Valleys; a catalogue of the flowering plants and vascular Cryptogams found in and near Lackawanna and Wyoming Valleys," (published privately with Charles O. Thurston from Wilkes-Barre, Pennsylvania) appeared as he made the decision to move.

Dudley's years at Stanford go beyond the current narrative. In time he became deeply involved with California forestry and especially with the conservation of archetype forests. He fought for, and won, the state's purchase of 2500 acres of prime redwood forest now known as Big Basin Redwoods State Park. David Jordan (Anonymous 1913) related: "Professor Dudley's health was good until about three years ago, when he set out to study the trees of Persia [the vast stretch of land from Egypt to Pakistan, centering in Iran; what is known now as "the Middle East"]. In Egypt he was attacked by a severe cold or bronchitis which ended in tuberculosis." Jordan's grace note: "He never married." Dudley died 4 June 1911, in Los Altos.

John Casper Branner on Dudley (Anonymous 1913): "In the latter part of his life certain of his traits became more prominent than during his younger manhood. He was always, and of necessity, a purist in every sense in which that word can be used. But as he grew older I imagine that his sensitiveness brought him more pain than pleasure, and to this I attribute the rather lonely life he led after coming to California."

Jared Treman Newman on Dudley (Anonymous 1913): "Like many noble souls, he was peculiarly sensitive. He was hurt often when no hurt was intended. He was often melancholy, sometimes almost morbid. It has always seemed so strange that one who gave so much and so constantly should not be always happy. Perhaps he made up for it in the intensity of his joys. While he was often misunderstood and while the number of persons who came close to him was not relatively large, yet few men have merited, or have known, in so large a degree, the love of their fellows."

A list of notable students that passed through Dudley's aura at Cornell appears here in Appendix 3. A similar list of such students at Stanford (Anonymous 1913) is easily three times the Cornell list.

Chapter 4. Mason Blanchard Thomas (16 December 1866–6 March 1912)

Born in 1866 in New Woodstock, New York about 25 miles southeast of Syracuse and just a few miles due south of Cazenovia and the birthplace of Albert Nelson Prentiss (born: 1835), it would be years before Prentiss would meet Mason Blanchard Thomas at Cornell.

Thomas (Fig. 3) prepared at Cazenovia Academy (probably a lapsus by Kent 1979, for the Cazenovia Seminary), 6 miles north of New Woodstock. In those years, to recruit new, qualified students, Cornell ran a program of competitive scholarships carrying stipends to defray expenses. Thomas won one of them and enrolled in Fall 1886. According to Kent (1979): "It is unclear why he chose to study botany."

Although Albert Prentiss was Botany Department Head, Thomas began early to work with William R. Dudley, at that time establishing his own course in histology. Dudley was an experienced and inspiring teacher, as well as a half-time investigator of plant disease in the Cornell Experiment Station. He was a proponent of understanding disease through laboratory analysis, particularly histological examination, joining the movement of bringing the laboratory into the classroom. Years later, this relationship bore fruit as "A laboratory manual of plant histology" (Thomas & Dudley 1894), even though both authors had gone their separate ways. Through Dudley, Thomas became acquainted and worked with microscopist Dr. Simon Henry Gage.

Awarded a B.A. in 1890, Thomas immediately enrolled in graduate studies aiming for a Ph.D., but the Cornell fellowship he occupied at that time expired in nine months, with no other predictable means of livelihood. So it was not Thomas's first choice when in the fall of 1891, he was offered and accepted a faculty position at Wabash College in far-off Crawfordsville, Indiana. He must have come with high recommendations: the position was as the Rose Professor of Biology and Geology, and he replaced John M. Coulter, one of the champions of laboratory-centered learning who left Wabash to become President of Indiana University. Thomas was 25 years old.

The contrast between Cornell, its location, student body, faculty, and campus, and Wabash College, with about 200 students, 15-20 faculty, and unkempt grounds, was stark, but as later reported, Thomas "hit the road running." The quality of Wabash students was high. For entry into the collegiate program, solid academics were required, including preparation in Latin and Greek. Wabash was the quintessential small liberal arts college, and students received a great deal of individual attention in small classes. According to

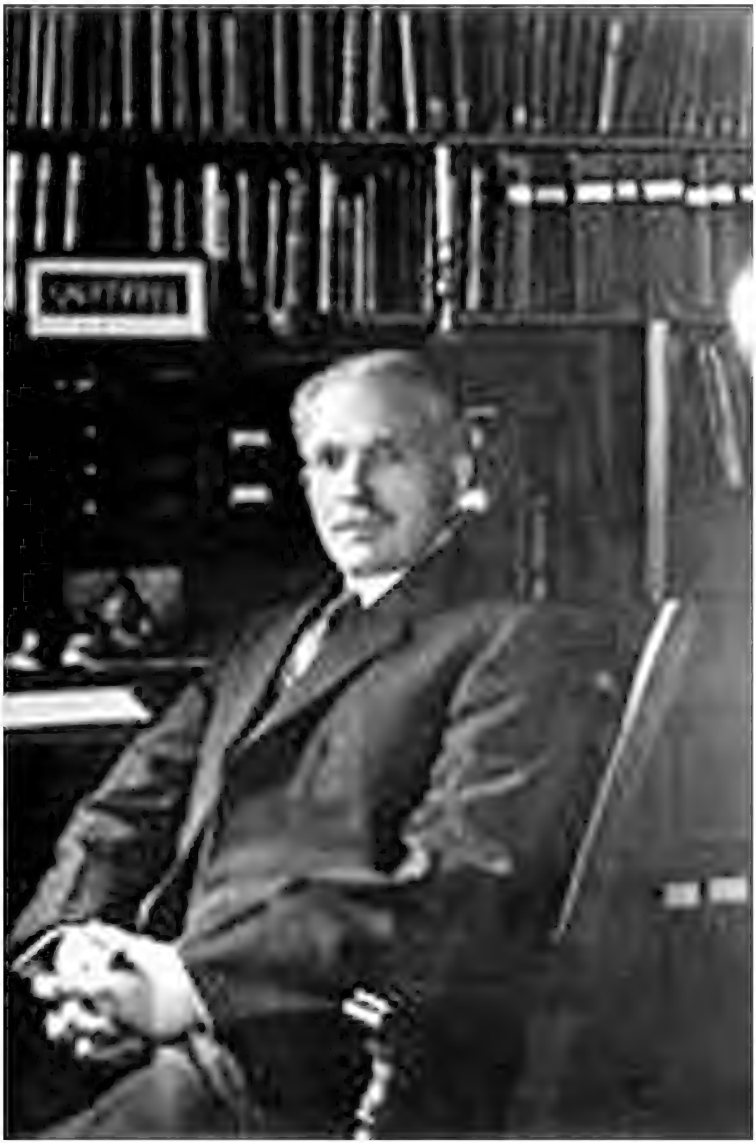


Fig. 3. Mason Blanchard Thomas. The Wabash Ambassador. 1969 vol.3(2): unpaged.

Kent (1979): "in his first year at Wabash, Thomas's remarkable energy and his interest in students led him to become coach of the new football team. During a practice session he received a knee injury which ended his coaching career,

caused him continual pain, and necessitated use of a cane for the rest of his life."

Most of the students were from the present-day mid-west and came to Wabash with no intention of studying biology. Many of Thomas's students reported how he advised them to take his general course, then encouraged them to major with him, and, finally, directed them to graduate school.

Lexemuel Hesler's description (Petersen 1979) of his first encounter with Thomas mirrored that of many students. As told in the third person, "… he entered Wabash College with the intention of transferring to Purdue University for a degree in Civil Engineering. After two years, however, his goal changed to botany. He recalls that at registration in the Fall Quarter at Wabash in 1907, his course of study was prepared by Professor Mason B. Thomas. He found Thomas a magnetic and persuasive personality, which resulted in Hesler being signed up to take freshman botany. His performance in Thomas's course that year scarcely sparkled. A conference which Hesler had sought with Thomas at the end of the first quarter opened a new understanding by this freshman as to what college was, and what it took to do profitable college classwork. Things were now to change for the better. However, in the following year [junior], he met another student, one Jacob R. Schramm [Wabash class '10, one year ahead of Hesler; see Appendix 4; Table 1)]. Soon Hesler's professional life-plan was well laid by the designers Thomas and Schramm. In this plan was Hesler's assignment to assist Schramm at the Woods Hole Biological Station, in Massachusetts, during the summer of 1909; and the next summer (1910) he was placed in the field station at Sodus, New York, on the recommendation of H.H. Whetzel, Wabash '02' [by then on faculty at Cornell]. This move resulted in Hesler's appointment to a fellowship the following January 1911, at Cornell. At Cornell, Hesler held the fellowship in Plant Pathology."

In 1892, only a year after Thomas's arrival at Crawfordsville, campus gossip was rivaled by different news headlines. Negotiations were underway to designate a location for an exposition commemorating the 400th anniversary of Columbus's arrival in the "New World." Two cities led the competition, New York and Chicago. The New York bid seemed insurmountable, backed by the likes of J.P. Morgan, Cornelius Vanderbilt, and William Waldorf Astor. Chicago's bid was underwritten by Charles T. Yerkes, Marshall Field, Philip Armour, Gustavus Swift, and Cyrus McCormick among others. The final straw came when Lyman Gage, the Chicago Banker, raised over a million dollars in 24 hours to top New York's bid. The "Windy City" site was finalized.

The site was to be grand, with lakes, ornate buildings, and participation by many nations up and down the Americas. Its title was World's Fair: Columbian Exposition. In all, 46 countries participated, each advertising its own society, culture, products, and beauty. State exhibits included California, Connecticut, Florida, Illinois, Louisiana, Massachusetts, New Jersey, New York, Pennsylvania, and Texas.

Fourteen "great buildings" were included. Among them were Agriculture, Forestry, and Horticulture. William Ashbrook Kellerman, a former Prentiss/Dudley student at Cornell (see APPENDICES 2, 3) and by 1893 the botany department head at Ohio State, mounted an exhibit of Ohio timber trees. Charles Horton Peck, State Botanist for New York, brought numerous ceramic models of mushrooms and other fungi. Joseph Charles Arthur, from Purdue, exhibited a physiological apparatus of original design, "receiving medals and diplomas." (Lloyd 1920). The agriculture building included displays of U.S. Department of Agriculture-aided crops and new motorized technology for the farm.

The exposition was dedicated 1 October 1892 and opened to the public 1 May 1893. During its six-month life, over 21 million people went through the turnstiles. It was a headline-stealer and a living symbol of the resilience of Chicago after its disastrous fire of 1871.

Inspired by the Fair's exhibitions, William Powell Wilson, once a Prentiss student at Michigan State (see APPENDIX 1) saw an opportunity. Wilson imagined a permanent commercial museum with exhibits along the style of those at the Exposition. Perhaps exhibits from Chicago could serve as the beginning. Already a botany professor on faculty at the University of Pennsylvania, he quickly returned to Philadelphia and floated the concept through local authorities. Armed with official approval and adequate funding, Wilson returned to the Fair and persuaded several Central and South American countries to sell their Exposition exhibits to his yet-to-be-housed museum. The concept was a success, the museum grew and eventually moved to a building of its own, which it occupied until its closure in 1994. Wilson spent the rest of his career searching out exhibits for the Philadelphia Commercial Museum, an occupation which made him a respected international statesman.

To resume the interrupted narrative, in 1893, Mason Thomas, age 27, married Anne Davidson, a young lady from Crawfordsville, who shared his warm personal relationships with students. Even after Thomas's death she retained the affection of many Wabash students. The Thomases had no children (Kent 1979).

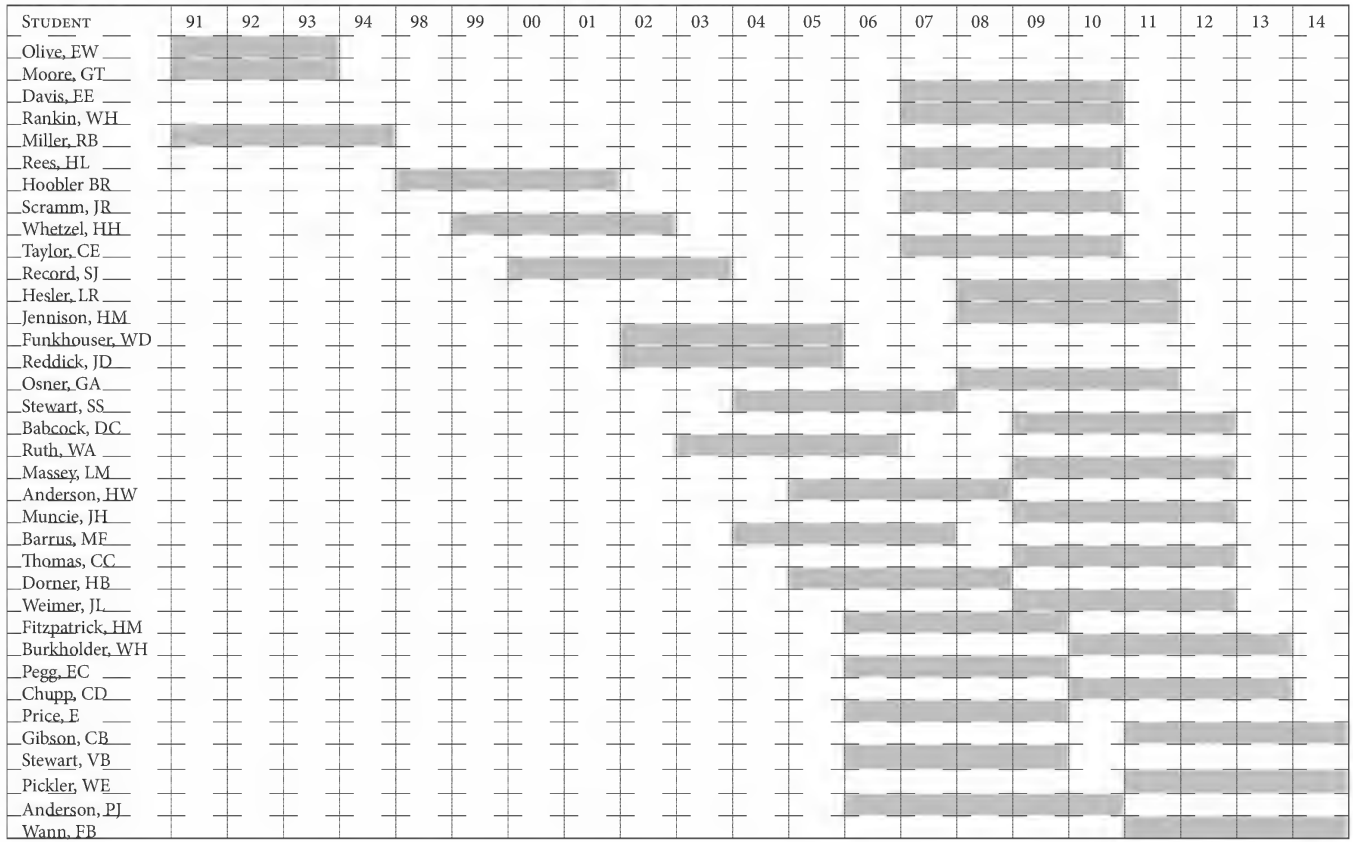
In response to student popularity in the natural sciences at Wabash, botany was divided in 1895. Thomas was titled Professor of Botany, with Dr. Donaldson Bodine as Professor of Biology and Geology. The two complimented each other in pedagogical philosophy and they became fast friends.

Perhaps as evidence of his energy, Thomas was sometimes viewed as a gadfly. He vociferously carped on the poor appearance of the campus grounds, and so in 1897, in a common administrative tactic, he was appointed by the President to oversee the buildings and grounds. Thomas promptly persuaded the Executive Committee of the Trustees to bring in a landscape architect to develop a landscaping plan for the campus. It was his first formal attempt at administration.

As the growth of urban New York City was contrasted to the opening of Cornell University in 1868, the first quarter of the 20th century saw the first operational underground rapid transit system. Two private companies pioneered the construction, and the first New York city transit route opened in 1904. By 1913, the City took over new construction, leasing the routes and stations to the companies. Apace, Chicago opened its "L" (elevated rapid transit system) where four routes and four companies began service between 1892 and 1900. Whether measurements were based on geographic area, population, residence density, gross domestic product, the arts, or pollution and general filth, at every turn, the dominant cities grew and thrived usually with little knowledge or opinion about rural, agrarian conditions over the horizon.

During the ensuing years, Mason Thomas's reputation grew, both as teacher/mentor and effective administrator. A list alone cannot cover the duties and roles as well as the esteem given him. Associate Editor of the Proceedings of the Indiana Academy of Sciences, 1899–1900, followed by the Presidency, 1900–01; fellow of the American Association for the Advancement of Science and appointment to its Counsel; Secretary of the Indiana Forestry Association and Chairman of its Education Committee; Member of the Corporation of the Marine Biological Laboratory at Woods Hole, Massachusetts. Almost tangential was his interest in the Boys School of Plainfield, Indiana, for which he served as Secretary of the Board of Trustees. His performance in all roles led to his appointment as Dean of Faculty in 1907, in addition to his regular departmental responsibilities, over which he remained head until 1908 as a faculty of one. His mentored students kept pace, with most graduating during 1905–1914 (two years after his death; Table 1). Wabash appreciated his role in the College and in 1907, awarded him an honorary LL.D. degree.

TABLE 1. Thomas students and their times at Wabash College, 1891–1914



In January 1912, Thomas became ill and was confined to bed with what was diagnosed as severe pleurisy, an infection of the membranes surrounding the lungs. For two weeks he continued to conduct classes at his bedside. As he continued to decline, his former student, Dr. B.R. Hoobler (see Appendix 4; Table 1) came to Crawfordsville to assist in his treatment. Thomas died on 6 March 1912, at age 45. As written by Kent (1979): "At the turn of the century, one of the outstanding teachers of botany in the United States was Mason Blanchard Thomas at Wabash College."

Memorials and obituaries for Thomas were several (Anonymous 1912a,b; Mills 1912). From his first year at Wabash to his last, Thomas selected and mentored students and propelled them toward more significant goals. An annotated list offered by Kent (1979) appears as Appendix 4.

Chapter 5. Herbert Hice Whetzel (5 September 1877–30 November 1944)

As might be expected, excitement over the "New Botany" pedagogical innovations led to some differences of opinion. This dichotomy played out in microcosm at Cornell, with the conservative Albert Prentiss as its botany head in the College of Liberal Arts followed by George Atkinson, and the later Liberty Hyde Bailey's more energetic State College of Agriculture with its version of a Botany Department (soon renamed). Bessey, John Coulter, J.C. Arthur, Dudley, Kellerman, and others were eager to push the discipline forward by promoting botanical education at all levels (Sundberg 2014).

The narration for Herbert Hice Whetzel (Fig. 4) includes, of course, some facts of his life, but the circumstances at Cornell during his graduate student days and those of his retirement from the department headship oblige additional words, for the effects of those academic political episodes were felt throughout the phytopathological, mycological, and academic communities.

Born in Avilla, in the upper east corner of Indiana, Herbert Hice Whetzel (Wabash class of 1902) became a formidable, albeit controversial, force in plant pathology. Of Whetzel's early life little is recorded except that a teacher noted Whetzel's devoted hobby of collecting and preserving botanical specimens and encouraged the young man to extend his education beyond public school (Fitzpatrick 1945). Whetzel graduated from Avilla High School in 1895. Two years of local school teaching followed before he arrived at Wabash College. His choice of Wabash remains oblique, but as the qualifications for entrance were stringent, Whetzel must have been thoroughly prepared, including familiarity with Latin and Greek. There may have been a prior connection to Prof. Mason

Fig. 4. Herbert Hice Whetzel. L.R. Hesler, pers. comm.

Thomas there, for Whetzel lodged with the Thomases and so had ample time to absorb the professor's magic. A worrisome vision problem led Whetzel to drop out of college for a year, but when he returned, Thomas's previous Cornell experience with and under Prof. W.R. Dudley paid off for Whetzel. As a junior, Thomas arranged for Whetzel to become a summer assistant to George Atkinson, the botanist at Cornell, and that summer Whetzel, Atkinson, and Atkinson's student, Calvin H. Kauffman, collected fungi together.

Whetzel must have excelled at Wabash, for after graduating with a B.A. in the class of 1902, he simply moved on to Ithaca, New York, to become Atkinson's graduate student. Just a decade previously, the Hatch Act had given state colleges the opportunity to fund agricultural experiment stations. For Cornell it only meant additional funds, for its station had been founded in Geneva, New York, a few years before. J.C. Arthur, one "New Botany" advocate, was the botanist at the station. Atkinson's campus appointment in botany also carried responsibilities at the Station, usually carried out by Atkinson's students under his supervision. Whetzel was no exception. Within a year, the celebrated Liberty Hyde Bailey joined the Experiment Station. Graduate student Whetzel was there to see it all.

Whetzel's migration came at a moment when headlines were made in another direction. Just a decade after the Columbian Exposition in Chicago, the anticipated Louisiana Purchase Centennial Exposition was held in St. Louis. Like its predecessor, architecture was grand, with 60 countries and 43 American states represented. Scientific attractions emphasized technology, perhaps reflecting the changing demography from agrarian to urban populations. St. Louis was (and is) considered "The Gateway to the West" and its location on the WEST side of the Mississippi was significant. Some 19.7 million visitors took in the fair, which cost the federal government $15 million dollars.

Whetzel's responsibilities at the Geneva Station brought him into contact with Bailey, who offered him a job as an extension agent, bringing the research from the Station to the farmers who needed it (Fitzpatrick 1945). But Bailey was soon tapped by the New York State administration to establish the New York State College of Agriculture at Cornell University (Colman 1963). Meanwhile, Whetzel was promoted to Assistant Professor in the Liberal Arts botany department. The new College, however, also planned a department of botany, awkward since Atkinson's botany department already existed. The solution to the naming problem came in two phases: [1] Bailey offered Whetzel a new job as Assistant Professor and Head in the new department, so for some time he would be on faculty in two botany departments in two

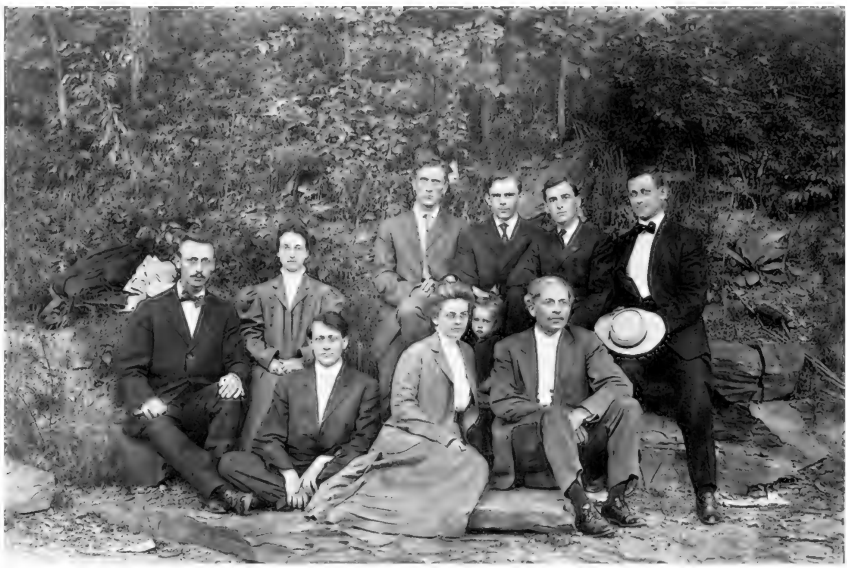


FIG. 5. Reunion of Wabash graduates at Cornell University, 1908. Left to right: Donald Reddick, Mrs. Whetzel, Prof. Herbert Whetzel, Earl Price, Mrs. Thomas, young Gertrude Whetzel, Harry Fitzpatrick, Prof. Mason Thomas, Jacob Schramm, Delbert Funhouser. Photograph taken on rocks above second bridge beyond Forest Home. Courtesy: Cornell University, Plant Pathology Herbarium (CUP).

colleges; and [2] Whetzel soon requested that the new botany department be retitled as the Department of Plant Pathology, of which he would be the head. In Whetzel's (1945) own words: "In the spring of 1906, he [Bailey] disclosed to me his intention of establishing a department of botany and offered me the job of organizing it. The following autumn I was made assistant professor of botany and head of the department" [of Plant Pathology in the College of Agriculture].

This titular redundancy was, of course, awkward. Although somewhat confusing for a reader not familiar with the sub-sciences involved, the explanation may be opaque. According to Korf (1991): Whetzel's teaching of "most important parasitic fungi" (Botany II – mycology) had much earlier been offered by Atkinson and Durand in the Department of Botany [Liberal Arts], and by 1906-07 a course in Methods of Research in Plant Pathology was also offered in the [agriculture botany] department." Once the [agriculture] Department of Plant Pathology existed, "Two courses were offered in 1907-08, 1a — Plant Pathology and 2a — Methods of Plant Pathology, both taught by Whetzel and Donald Reddick, one of the 'Wabash boys' (see FIG. 5). By 1908-09 five courses, plus seminar and research, were offered by Whetzel, Reddick, and

another of the Wabash group, M.F. Barrus (Wabash class of '07)." Whetzel kept control of the introductory courses for the rest of his career, teaching them for the last time in 1943 (Korf 1991).

Back to Whetzel's testimony: "... In the summer of 1907 I decided to devote my effort entirely to the development of plant pathology as a field for teaching and research. I went to Dean Bailey with the request that my title be changed from assistant professor of botany to assistant professor of plant pathology and that I be relieved of responsibility for the work in other phases of botany. Apparently astonished at my temerity in suggesting an entirely new kind of chair in university faculties, he, nevertheless, consented to put my proposal before the Board of Trustees of Cornell University. When my appointment came through that autumn, it carried the title of assistant professor of plant pathology and head of the new department."

Sadly, in 1912, he was widowered, but later the same year he left for a 15-month-stay (1912–14) in Europe, with a residency at the University of Heidelberg working with Prof. Georg Klebs. Shortly after his return, two events burdened Whetzel's life. First, L.H. Bailey resigned the Deanship of Agriculture, thus removing a sympathetic ear in administration. With this change the future of the "New Botany" was put at risk.

According to Hesler (1975), an eye-witness: "In 1914, [Beverly Thomas] Galloway was induced to accept the deanship of the New York State College of Agriculture, at Cornell University. The move proved to be a disaster, both for him and for Cornell.

"Before coming to Cornell, although Galloway had had little or no academic administrative experience, he had been persuaded by Whetzel and others to accept the deanship there. It was unfortunate for him that he should follow at Cornell so skilled an administrator as Liberty Hyde Bailey. Galloway brought with him from Washington some of the Federal Bureaucracy practices in vogue there, and somehow these were both unfamiliar and unacceptable to the Cornell Agriculture faculty." He was also resistant to "New Botany" teaching philosophy. "Galloway's inaccessibility to the faculty, his ineptness in handling the legislature to get funds, and his general image all resulted in a few special faculty meetings (which [Hesler] attended) to discuss what the faculty felt was a grave problem. The net result of all this activity was pressure that was applied in such a way that in 1916, Dr. Galloway was led to resign. He then returned to the USDA where he pursued his work in plant pathology until retirement." For his part, during these same years Whetzel also served as 1915–18 President of the American Phytopathological Society.

In a second, then seemingly insignificant, event of 1914, the June assassination of Archduke Franz Ferdinand, heir to the Austro-Hungarian Empire sparked a diplomatic confrontation that quickly boiled over into World War I. Whetzel served energetically as Chairman of the American Phytopathological Society's War Emergency Board.

Now, in order to set the stage for the subsequent decade, some words must be added about Whetzel's personality. Bailey's choice of Whetzel as the person to translate the research of the experiment station into "normal language" testifies to Whetzel's affability and facility with language, and he was a persuasive evangelist. But as years passed with him at the helm of the department, some of his more energetic projects and idiosyncrasies began to chafe younger faculty who did not wish to subjugate themselves to authority. A few vignettes testify (enumerated for separation).

[1] Korf (1991): "One of the most unusual and to my mind most important features of Whetzel's course was that each student was held to complete 16 oral examinations, each on one week's work. These examinations were given both by laboratory instructors and by those professors in the department who might have worked with the disease studied that week. By virtue of Whetzel's commanding and demanding personality, almost every professor in the department took part in these oral examinations, usually lasting 20 to 30 minutes in that professor's office." The elapsed time for each examination was multiplied by the number of students enrolled in the course – time taken away from the professor's own teaching and research. Fitzpatrick (1945): "[Whetzel] applied an entirely new system of teaching perhaps on the English system, and belittled those who did not adopt it." Convinced of the value of his teaching style, Whetzel (1930) published on it.

[2] Whetzel considered the herbarium the backbone of the department (Korf 1991). He adopted a numerical system so that everyone could find a specimen and additions were placed at the end of the run. Individual herbaria and other specimens were frowned upon. The departmental herbarium was coordinated with slides, photos, notes, etc. under the same numbers. Although revealed as an efficient system, faculty discussion and approval were not sought. Fitzpatrick (1945): "...and though at times in his enthusiasm for organizing, he promulgated regulations approaching regimentation his motive in so doing were not selfish..."

[3] Korf (1991): Instead of each faculty sequestering his own instruments and reagents, Whetzel organized the first Plant Path stockroom—with check-out slips.

[4] Instead of each professor staging and executing his own photography, Whetzel placed one man in complete control of the department's photographic facilities and had him do all of its photography.

[5] Even technical terminology was not overlooked by Whetzel. Fitzpatrick (1945): "It must be conceded that in coining new terms, as in some other respects, he tended to be somewhat radical, and clearly took pleasure in nettling the ultraconservatives." Again, Whetzel (1929) was convinced that his terminology was salutary and published on it.

[6] Korf (1991): "The few [faculty] I did not meet in [these oral examinations] soon became acquaintances through the regular departmental afternoon coffee hour, attendance at which was 'expected' by Whetzel, whose sonorous, booming clarion call on a rising and then declining pitch, "Coffee, coffee," shook the whole building daily.

[7] Before his step-down from the headship, Whetzel (1918) published a major offering "An outline of the history of phytopathology," regarded by some as preemptory.

[8] Harry Fitzpatrick (Wabash '09), groomed by Thomas and molded by Whetzel, was by now on faculty in Plant Pathology at Cornell (hired specifically to teach mycology). Newhall (1980): "Fitz[patrick] hated cigar smoke and Whetzel smoked much of the time. He particularly liked to stand in Fitzpatrick's doorway and TALK AND PUFF and watch Fitz squirm. Fitz would later slam open the door and window and then go for a walk."

In 1922, Whetzel stepped aside as department head, succeeded by Louis Melville Massey (Wabash class of '12) who occupied the position until 1950.

The questions which surround the faculty discontent and Whetzel's retiring as department head to my knowledge are dealt with in only one paper (Jones 1922). Extended quotes from that short publication are warranted. Although the paper occupies only two journal pages, not all is germane to this narrative. The following quotes have been extracted.

"Professor H.H. Whetzel, who has been for fifteen years head of the Department of Plant Pathology of Cornell University College of Agriculture, retired on July 1 [1922] from the administrative leadership in order to devote his time and energies more fully to teaching and research together with the immediate preparation on one or more text books. Dr. L.M. Massey who has been acting head for the past year during Professor Whetzel's absence in Bermuda succeeds to the permanent position.

"When I last visited Cornell a year ago the Department had in addition to what were doubtless the largest undergraduate classes of any like department

in America, an enrollment of twenty-six graduate students. It has during the last thirteen years granted twenty-four Ph.D. degrees with major interest in plant pathology. … Whetzel has in his work, shown a genius for meeting old problems in a new way in the field of phytopathology.

"In a letter to his dean setting forth his reasons for wishing to retire from the headship, Whetzel says: 'I am convinced that with rare exceptions no man should be allowed to head a department for more than fifteen years. He should not serve for less than ten, unless he is a failure – then the sooner he steps out or is removed, the better. The head of a department who cannot in ten or fifteen years put over a big administrative project deserves no further time or opportunity.

"'… Few men can do both administration and teaching, let alone research also with full justice to all. After ten years of administrative work I long to give my time and energies fully to teaching and research work. As you know, I have for four or five years urged you to relieve me of the headship that I might devote myself wholly to my students and my investigations. I feel that another ten years would not only measure the span of my administrative usefulness but would also end any possibility of a successful return to teaching or research.

"'One of the most disastrous features of long tenure headship is its effect on ambitious and able young men in the staff. Such men see little hope of administrative opportunity within a reasonable period of time and either leave the institution for a better position elsewhere or become discouraged, discontented, often intriguing and disloyal to the chief. The result in the latter case is sure to be disastrous to someone, usually to the young man himself, often to the department and to the institution, not infrequently to the good name and prestige of the head of the department himself.'"

As to the question of whether Whetzel recognized the restive state of his faculty, the answer is affirmative, but he judged this as disloyalty to the head. Complaints were caused by lack of administrative opportunity as long as the head blocked upward mobility.

His reference to four or five years of request for relief from administration, given his style, success with "industrial fellowships" and numerous other innovations rings hollow. In fact, the request must have fallen on the deaf ears of the dean. Of course, Whetzel had a model in the brief term of Dean Galloway, who lasted only two academic years under duress.

It is difficult to splice "I am sure a younger man can carry it forward farther and with greater success than I could now." The word "now" could

refer to Whetzel's age or tenure in office, or it could refer to his wounded status in regard to faculty distaste for his headship. But the entire paragraph describes his role in the expansion and progress of the department. All told, the letter reads like that of a captain facing mutiny, but who cannot stand down without justification and self-praise. What a humbling situation to which to return from protracted research in Bermuda. Massey maintained the headship from 1921 to 1950 (29 years), somewhat longer than what Whetzel might have thought advisable.

If Whetzel's idiosyncrasies as department head were considered negative (and they were so by the increasing cadre of young faculty; Korf 1991), Whetzel's crowning achievement was establishment of "Industrial Fellowships." This program, while bringing increased funding, was controversial for perceived mixing of college, "pure" research with the commercial world's money. When plant pathology became an administrative unit in 1906, in Whetzel's (1945) own words: "I soon found out that the sum which the Dean [Bailey] was able to assign for the maintenance of the department was quite inadequate to meet the demands for the solution of plant disease problems of pressing importance in the State, and I began to cast about for other sources of funds for research." The first such fellowship started in 1909.

The "Industrial Fellowships" program took hubris on Whetzel's part. After ascertaining that a particular phytopathological problem could be ameliorated by research in his department, the potential commercial sponsor had to be contacted, informed of the benefits, and agree to a sum, all within Whetzel's comfort zone. Further persuasion was required: "It was early found that the cost to the department in supervision, equipment and administration of the work was approximately equal to the value of the fellowships themselves. Thus the State was compelled to provide increasing allotments to the Department of Plant Pathology to meet these requirements." "...we may conservatively say that well over half a million dollars have been made available to the department during the past 36 years." (written in 1945).

Pedagogically, the Industrial Fellowships turned laboratory-centered instruction on its head. In addition to bringing real organisms and real agricultural problems into the classroom for student consideration, they immersed the student in the "real world" laboratory to experience both the problem in question and the real economics of the crop and business of agriculture.

Whetzel (1945; Appendix 5) himself offered a detailed listing of the fellowships, their recipients and the money involved. He summed up the

program: "Of the 67 who have held one of these fellowships, 42 have received the doctorate degree at Cornell University and 2 elsewhere; 31 have become research professors or teachers in colleges or universities (9 at Cornell); 18 have become investigators (at professional stations) in the Federal service or in commercial organizations; 2 have turned to farming; and 6 are currently fellows in the department of plant pathology at Cornell."

Although the "Industrial Fellowship" program continued after Whetzel's retirement from the headship, they then required approval from above and were subject to "outside" accounting and lobbying for the state's contribution to the department's research. In the midst of such activity, in 1930, he again spent eight months in Europe.

According to institutional regulations, members of the faculty could not be awarded a degree by the same institution. Whetzel, therefore, could not receive a Ph.D. from the State College of Agriculture even though his research was far more than otherwise would have been acceptable. The years of serving on faculty, as department head and return to teaching and research were borne on a Bachelor of Science degree from Wabash College, class of 1902. In 1906, Wabash conferred on him an M.A. and later in his life, an honorary D.Sci. in 1931. A frequent field companion was Carlos Chardon, former Cornell student under Whetzel, Chancellor the University of Puerto Rico and later Commissioner of Agriculture and Labor. Honoring his field work and advocacy, the University awarded Whetzel an honorary D.Sci. in 1926.

Well before his retirement from the headship, Whetzel had become interested in plant pathogenic fungi whose sexual-state apparatus arose from sclerotial structures, especially members of the genus *Sclerotinia*. Now, upon relinquishing administrative duties, he had time to devote to this group and did so for the rest of his life. A score of publications appeared, and travel was undertaken to seek out the foreign species. Especially interesting was the variety of the asexual expressions, which often proved the only way to distinguish species of the group. His first publication on this subject dated from 1926 (Whetzel 1926), followed by 11 taxonomic contributions over the rest of his life. Fitzpatrick (1945): "Though Professor Whetzel in his earlier days had directed most of his investigations toward the solution of economically significant problems in plant pathology, his interests were always largely mycological, and his work on the *Sclerotiniaceae* during the last twenty-five years of his life was unquestionably his major accomplishment in research." It was Fitzpatrick who assembled Whetzel's posthumous last paper.

From his early days in the schools of Avilla, Whetzel was a collector of biological specimens. This curiosity never left him, and during his later years he participated in travel, now with a mature outlook and almost always with one or two companions. Venues included Puerto Rico in 1916, 1924, and 1931; a sabbatical 1921–22 in Bermuda and return in 1926; 1939 in Venezuela, all adding to the department herbarium – operating under the Whetzel numerical system.

Far from withdrawing from departmental activities, Whetzel soon was appointed a member of "The Committee of Three" (Whetzel, H.C. Coles, B.M. Duggar, a student of Atkinson and on faculty in the Liberal Arts Department of Botany) that organized the International Congress of Plant Sciences (a.k.a. Fourth International Botanical Congress) that met in Ithaca in August 1926. The Congress brought together mycologists and plant pathologists with botanists of all other fields. Whetzel was placed in charge of local arrangements, always a complicated task with little credit. In 1931, he attended the Fifth International Congress in Cambridge, England. Also in 1931, Whetzel was among the charter members of the Mycological Society of America, serving as its President in 1939, and the American Phytopathological Society in 1939. In the same year, Whetzel was widowered for the second time. Still, his teaching and research went on. Korf (1991) reported that Whetzel taught the Introductory Plant Pathology course for the last time in 1943. In 1944, Whetzel died and was buried in Ithaca, his personal and professional home for 44 years. Eulogies and memorials were many and sincere (Barrus & Stakman 1945).

Chapter 6. Wrapping it up.

This narrative deals with a sub-science within biology, namely botany, and two of its even narrower disciplines, mycology and plant pathology. Of these, every developing society must deal first with plant pathology—the failing of crops from unknown causes. Once it is established that such failures may be caused by parasitic organisms (i.e., by the application of Koch's Postulates), often taking decades, the door is opened for the study of the parasitic organisms themselves. This, in turn, invites study of similar but non-parasitic relatives—in the case of this narrative, the fungi, the science of which is mycology. The narrative opens soon after government (i.e., the Morrill Act of 1862) resolved to aid higher education in agriculture and mechanical arts, extends through the Hatch Act of 1887, granting support for state agricultural experiment stations, turns the century page, and terminates in the first half of the 20th. Using the

Fig. 6. Herbert Hice Whetzel, Joseph Charles Arthur, Harry Morton Fitzpatrick.
On the steps of Bailey Hall, Cornell University.
Courtesy Cornell Plant Pathology Department (CUP).

example of the four starring workers, a Malthusian explosion of research and teaching was in place well before World War II.

Farlow returned from Europe in 1874 chastened by the better botanical preparation of students than that of their American counterparts (Farlow 1876). Student Charles Bessey chafed when a microscope was locked away from botany students. J.C. Arthur wrote about pumpkin stems and exhibited a physiological apparatus at the St. Louis World's Fair. Herbert Whetzel constantly petitioned administration for more funds with which to equip classrooms with instrumentation. All these and more trace the growth of laboratory-centered instruction. Course popularity (and therefore enrollment figures) seemed directly related, and other sciences followed suit. As though by accretion the pedagogical movement morphed into the "New Botany." By the present day, the "New Botany" is an old proposition, largely dusty and overlooked, but the concept served, and continues to serve, as the basis for almost all college-level botanical (and therefore mycological and plant pathological) academics. Add to this the "Socratic" question and answer and the student becomes an investigator and the professor a consultant (Farlow 1913).

Almost all of the miniature biographies included here show men (sorrowfully, history does not document an equal role for women) who came from rural

backgrounds, typically from a farming lifestyle. Were the narrative to deal with the birth of accounting, the growth of classical music, the growth of the retail mercantile or progress in architecture, other societal roots might be revealed, but this is not so here.

Once the members in the narrative graduated from public schools, they often began a career in local school teaching. Wages were terrible, but there is a subtle point that after knowledge was personally absorbed, these young men had an internal urge to share their knowledge with a broader audience. When public school was insufficient, there came college, and after college, graduate studies. Ultimately, the urge to teach meant that the accumulated knowledge was again shared with others, namely (in this case) farmers and new generations of students. This urge to learn and to share knowledge predates the Common Era and will continue forward.

Although a strong strain of independence as part of the American society can be identified, there was an abiding attraction to European culture, not only for the arts and sophistication but also for the progress and breakthroughs emanating from the leading laboratories of the Continent. All four stars in the narrative not only participated, but repeatedly returned to Europe for study with leading scientific figures and consultations at herbaria, museums, and international meetings.

Essentially the same evolution can be written about ground transportation during the period in question. For example, Atkinson's appointment at Cornell combined the experiment station in Geneva and the campus in Ithaca, so it was necessary to travel back and forth. Horsepower was not merely a measurement of power but a mode of transportation. The distance between the two points was about 50 miles, easily a two-day trip, with livery stables, eateries, and lodging necessary. Railroad transportation between the campus and the station came late in the 19th century and was slow and sooty. The model T Ford was not readily available until after 1910, and roads were constantly ill-tended and tires questionable. Progress in plant pathology research depended to some extent on other societal progress apace.

Of the four stars in the narrative, three lived almost to an age normal for that era: Dudley to 70, Whetzel to 67, and Prentiss to 66. Only Thomas died prematurely at 46. These days (2020—pre-pandemic), all could have expected an additional 15–20 years, and Thomas 30.

Although Wabash College is featured here, the role of the small liberal arts college has remained clear, whether as a terminal degree or, here emphasized, preparation for graduate studies. During my own college years, we were

reminded of the value of connections with alumni, just as Mason Thomas made use of his Cornell years and his teacher George Atkinson and ex-student Herbert Whetzel for the benefit of his students. (see Fig. 6)

In 1880 (Anonymous 2020a), New York State established its Agricultural Experiment Station in advance of the 1887 Hatch Act and Michigan (1888) soon followed suit. They were not the first, but after 1887 and the Hatch Act, numerous other states took the federal scrip so within a decade several such stations existed, almost always part of land-grant universities. The growth and sophistication of research over the subsequent 140 years—including all mechanical/technological advances, from tractors, irrigation, fertilizers, drones, and reapers to soil science, computers and DNA sequence technology—have not only fed the nation but much of the world.

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Appendix 1.

Notable Prentiss students at Michigan State

Charles Edwin Bessey (1845–1915). Born: Milton, Wayne County, Ohio. Michigan State College 1866, B.S. 1869. Intended to be a civil engineer. 1869 Professor of Natural History, Iowa State College (Ames). Met Asa Gray at AAAS meeting, went to Harvard – no Ph.D.? 1886, left Iowa State; Chair of Botany at University of Nebraska. 1891 taught a course with laboratory at University of Minnesota.

Byron David Halsted (1852–1918) Born: Venice, NY. Michigan State B.S. 1871, M.S. 1874. 1885–89 Professor of Botany, Iowa State College. 1889 until death, Professor of Botany, Rutgers College & New Jersey Agricultural Experiment Station.

Samuel Mills Tracy (1847–1920) [data missing from Hesler 1975] Born: Hartford, Vermont. Union Army. Michigan State Agricultural College: B.A. 1868, M.A. 1871. 1871–77 Horticulture at Michigan State University. 1877 Professor of Botany, University of Missouri. 1887–88 collaborated with B.T. Galloway who eventually served briefly as Dean of Agriculture at Cornell. 1888–97, Director of the Mississippi Agricultural Experiment Station, Starkville.

William Powell Wilson (1844–1927), Born: Oxford, Oakland Co., Michigan. Orphaned when very young, lived and worked on a farm. Entered the State Agricultural College of Michigan in 1864. In 1873, became assistant to Dr. Goodale at Harvard, recommended by Asa Gray; B.Sci. 1878, Lawrence Scientific School. Graduate studies in Europe, 1878–80. Awarded D.Sci., from Tübingen University (Germany). Upon return settled in Philadelphia as Professor of Botany, University of Pennsylvania. At the Columbian Exposition in Chicago, 1893, conceived of economic or commercial museum for Philadelphia; museum established and Wilson became an international diplomat.

Appendix 2.

Notable Prentiss students at Cornell University

(Annotated from Atkinson 1896b)

Joseph Charles Arthur (1850–1942). Cornell Experiment Station; Professor of Vegetable Physiology at Purdue University.

Frederick Vernon Coville (1867–1937). Chief of the Division of Botany of the U.S. Department of Agriculture.

William Russel Dudley (1849–111). Professor of Botany in the Leland Stanford Jr., University.

Romeyn B. Hough (1857–1924). author of the classic 17-volume American Woods.

Joseph Austin Holmes (1859–1915). Professor of Botany and Geology at University of North Carolina; later State Geologist.

William Ashbrook Kellerman (1850–1908). Cornell B.S. 1874, Professor and Department Head of Botany at Ohio State University.

William R. Lazenby (1850–1916). Professor of Botany then Professor of Horticulture at Ohio State University. When the biology department was split, Lazenby became Department Head alongside Kellerman.

Clarence Wentworth Matthews (1877–1928). Professor of Horticulture and Botany at State College of Kentucky; First Dean, College of Agriculture; National Bureau of Education during WW I.

Veranus Alva Moore (1859–1931). A bacteriologist at the Bureau of Animal Industry of the U.S. Department of Agriculture; Professor of Comparative Pathology, Cornell University; Dean of the Veterinary College, Cornell.

Appendix 3.

Notable Dudley students at Cornell University

Annotated from Anonymous (1913);
* = Also listed by Korf (1991)

*Arthur, Joseph Charles; B.S., M.S., Ph.D.
Professor of Vegetable Physiology and Pathology,
Purdue University, Lafayette, Indiana

*Atkinson, George Francis; B.Phil.
Professor of Botany, Cornell University, Ithaca, New York

Brady, William L.; A.B., A.M., Ph.D.
Professor of Botany, Syracuse University, Syracuse, New York

Chester, Frederick Dixon; B.S., M.S. Bacteriologist;
Director, State Bacteriological Laboratory of Delaware

Corbett, Lee Cleveland; B.S., M.S. Horticulturalist,
Department of Agriculture, Washington, D.C.

Coville, Frederick Vernon; A.B. Botanist,
Department of Agriculture, Washington; Head of the National Herbarium.

Craig, Moses; M.S.; Missouri Botanical Garden, St. Louis.

Densmore, Hiram Delos; A.B., A.M. Professor of Botany, Beloit College.

Durand, Elias Judah; A.B., D.Sci. Professor of Botany,
University of Missouri, Columbia, Missouri.

Gregory, Emily Lorina; A.B. Professor of Botany,
Barnard College, Columbia University, New York.

Henderson, Louis Fournquist; Ph.D. (Formerly) Professor of Botany,
University of Idaho, Moscow.

Hicks, Henry; B.S. Nurseryman, Westbury, Long Island. New York.

Hoffman, Harry Natt; B.Agr. Nurseryman, Elmira, New York.

Hough, Romeyn Beck, A.B. Professor of Forestry, Yale University.

Howell, Jenny Kirk; Ph.D., M.S. Teacher, Plainfield, New Jersey.

*Kellerman, William Ashbrook, B.S., Ph.D. Professor of Botany,
Ohio State University, Columbus.

Lazenby, William Rane; B.Agr., M.Agr. Professor of Forestry,
Ohio State University, Columbus.

Moore, Veranus Alva; B.S., M.D. Director,
New York State Veterinary College, Cornell.

Norris, Harry Waldo; A.B., A.M. Professor of Zoology, Grinnell College

Porter, Edna. Botanical Gardens, Buffalo, New York.

Rowlee, Willard Winfield; B.L., Sci.D. Professor of Botany, Cornell University.

Schrenk, Herrman von; B.S., A.M., Ph.D. Consulting Timber Engineer, Plant Pathologist, St. Louis, Missouri.

Smith, Theobald; Ph.D., M.D., A.M., Ll.D. Professor of Comparative Pathology, Harvard Medical School, Boston.

Snow, Julia Warner; B.S., M.S., Ph.D. Professor of Botany, Smith College, Northhampton, Massachusetts.

*Thomas, Mason Blanchard; B.S. Professor of Botany, Wabash College.

*Trelease, William; B.S., Sc.D., LL.D. Director, Missouri Botanical Garden, St. Louis, Missouri.

White, Charles David; B.S. Geologist, Geological Survey, Washington, D.C.

Yatabe, Ryokichi; B.S. (Late) Professor of Botany, Imperial University, Tokyo, Japan.

> The Dudley Memorial Volume (Anonymous 1913) also includes a list of Dudley's notable Stanford University students, a list easily twice as long as his Cornell students.

Appendix 4.

Thomas-mentored students to graduate studies

(Annotated from Kent 1979) In order of graduating class

Olive, Edgar William (1870–1972) '93

Edgar William Olive was the first botany student mentored by Mason Thomas at Wabash (class of 1893). Born in Lebanon, Indiana, Olive taught school in Boone County in order to pay for attendance at Wabash. After his A.B., he remained, becoming an assistant to Thomas and receiving an A.M. in 1895. Thereafter, he studied in the Cryptogamic Laboratory at Harvard University, earning an A.M. in 1897 and a Ph.D. in 1904. His thesis was "A monograph of the *Acrasiae*" (Olive 1902). An appointment at the University of Wisconsin was followed by a similar job at South Dakota State College. In 1916, Olive was appointed as Head of the Botanic Gardens at the Brooklyn (NY) Institute. A "second life" began in 1920 when he joined his brother in the family accounting firm in Indianapolis, Indiana. At the age of 80, he moved to Florida to join an investment and real estate project. Celebrated as the oldest Wabash alumnus at age 100, Olive died in Indiana.

Moore, George Thomas (1871–1958) '94.

George Thomas Moore was born in Indianapolis, Indiana. With Olive and Miller, he was among the earliest botanical students of Thomas at Wabash. In addition to Wabash (A.B., class of 1894), Moore received a B.A., M.A., and Ph.D. from Harvard and became Director of the Missouri Botanical Garden (from 1912–53; founded in 1914) and Engelmann Professor in the Henry Shaw School of Botany of Washington University. During 1909–19, he was Head of Botany at the Marine Biological Lab at Woods Hole, M.A. There he joined Jake Schramm, also a Wabash grad, and during summers, Mason Thomas from Wabash and Thomas's student, Lex Hesler.

Miller, Robert Barcley (1875–post 1948), '96

Together with George Moore and Edgar Olive, Robert Barcley ("Dusty") Miller—born in Lincoln, Nebraska but educated in Thornetown, Indiana—was an early Thomas student at Wabash (class of 1896). Armed with the A.B. degree, Miller was Assistant Principal of Thornetown High School in 1897-1898, becoming Professor of Natural Science at Rochester Normal School in 1899. There followed appointments at Dakota Wesleyan College and Huron College, both in South Dakota. He received an honorary M.A., also from Wabash, in 1906. Later that year, Miller enrolled in graduate studies at Yale's Sheffield Scientific School and was granted a Ph.D. in 1908. In 1909, he gained the position as Dean of Forestry, University of New Brunswick, Canada, but in 1914, became one of the earliest workers with the Illinois Natural History Survey. By 1929, Miller was listed as Chief Forester, Illinois Department of Agriculture.

Hoobler, B. Raymond (1872–1943) '01

B. Raymond Hoobler stayed for a Master's Degree in 1902 before attending Cornell Medical School (M.D. 1905). Only 11 years out of Wabash, he was at Thomas's bedside

during Thomas's last days. Serving at several leading hospitals, Hoobler became Chief of Medicine at Children's Hospital and Professor of Pediatrics at Wayne State University, Detroit, Michigan.

Whetzel, Herbert Hice (1877–1944) '02

Born in Avilla, in the upper east corner of Indiana, Herbert Hice Whetzel became a formidable, albeit controversial, force in plant pathology. In Avilla's secondary schools, he was several years ahead of Harry Fitzpatrick (q.v.) whose future Whetzel greatly influenced. As a student at Wabash, Whetzel lived with Professor Thomas's family and so had ample time to absorb the Thomas magic. Using contacts from his student days at Cornell, Thomas arranged for Whetzel to become a summer assistant to G.F. Atkinson at Cornell, and that summer Whetzel, Atkinson and Atkinson's student, Calvin H. Kauffman collected fungi together. Once the Cornell attachment was made, it was never broken and Whetzel served as Professor in Atkinson's Botany Department and eventually as Head of the new Plant Pathology Department until 1922. The events of this time period deserve a more detailed description (see the narrative), but one of Whetzel's innovations was establishment of "Industrial Fellowships" through which the agriculture industry supported phytopathological research to the benefit of the industry, to Cornell and to the supported students, including subsequent Thomas students from Wabash.

Germane to the outline of Whetzel's role in Cornell (and national) plant pathology, Whetzel was hired at Cornell by Liberty Hyde Bailey, the idealist humanist sociologist of rural living and Dean of the newly established New York School of Agriculture at Cornell University. Bailey was a bit of a "radical missionary," essentially devoting his life to the distribution of technical education to the masses of farm-oriented professions. His evangelism was replaced when new mechanization of disease control, soil improvement, and other aspects of farming resulted in over-production of crops. Family farms could prosper under these new and changing technologies. In 1913, Bailey resigned his position as Dean of the College of Agriculture and devoted the rest of his life to research, largely a taxonomic study of palms. It could be surmised that Bailey and Whetzel supported each other philosophically and enthusiastically.

Record, Samuel James (1881–1945) '03

A local boy from Crawfordsville, Indiana, Samuel James Record attended Wabash College, obtaining a B.A. (1903), M.A. (1906), and honorary D.Sci. (1930). A bit of a pioneer, Samuel was one of the first Thomas protégés to enroll at Yale School of Forestry, earning a Master's degree in 1905. After a stint with the U.S. Forest Service in Arkansas and Ozark National Forests, Record returned to Yale. In 1912, he published the first of his significant books, Economic woods of the United States, followed by Mechanical properties of wood in 1914. Both books went through second editions and became standards in the fields, with scanned versions available even now in 2020. A career of field trips over the world produced a large collection of wood samples and an encyclopedic knowledge of timber woods. By 1917, Record was a full Professor of Forestry, and in the 1920s founded both the International Society of Wood Anatomists

and the journal Tropical Woods. In 1945, he was placed in charge of tropical forestry and in 1939 was appointed Dean of the School of Forestry. Record was associated with Yale until his death.

Funkhouser, William Delbert (1881–1948) '05

William Delbert Funkhouser became a well-respected zoologist and anthropologist. Born in Rockport, Indiana, he graduated high school in Indianapolis before entering Wabash College. Although known as a practical jokester, he was a member of Phi Beta Kappa and graduated with honors. After three years teaching in high schools, he entered Cornell's Zoology Department, earning an M.A. (1912) and Ph.D. (1916; dissertation: Biology of the *Membracidae* of the Cayuga Lake Basin). During these years he also taught in Ithaca High School. An extra year was spent at Cornell as an "Honor Fellow," but in 1918, Funkhouser was appointed as Head of the Department of Zoology and Entomology at the University of Kentucky in Lexington. Several long-distance field trips, correspondence with appropriate authorities, and receipt of worldwide specimens of tree hoppers established Funkhouser's career, but opportunities were soon presented that quickly evolved into a parallel career in archeology, especially of Ancient Man in Kentucky. In 1925, Funkhouser was elevated to Dean of the Graduate School, a job which cut into his research time. In 1942 he served as president of the Entomological Society of America. He remained as Dean until shortly before his death of lung cancer in 1948.

Reddick, J. Donald (1883–1955) '05

In spite of being born in Missouri, J. Donald Reddick graduated from Wabash College in Indiana. He entered Cornell before the separation of the College of Liberal Arts and the New York State College of Agriculture. This distinction was to play a key role in Reddick's career. In the botany department he was an Assistant to Dr. George F. Atkinson who served as his major professor for the Ph.D. degree in 1909. In 1907, however, he was appointed the first Instructor in the new Department of Plant Pathology. According to Korf (1991): "[Reddick's] early duties at Cornell included the teaching of formal undergraduate courses in principles of plant disease control and the instruction of graduate students in the field of mycology and in methods in the study of plant diseases." In this way, Reddick reported to both Atkinson and Whetzel, but Whetzel retained Reddick in the new Plant Pathology faculty.

Reddick became well-known for his investigation into potato diseases. More particularly, recent research had indicated that the cultivated potato had its origins in Mexico, so Reddick travelled there to retrieve "primitive" stocks leading to hybridization experiments and resistance to common diseases. In those years Reddick also served as Editor of Phytopathology (1915–18), President of the American Phytopathological Society (1920), and Secretary of the Plant Pathology Section of the International Botanical Congress at Ithaca (1929).

Although tangential to this narrative, during 1918–21 the Plant Pathology faculty grew impatient with Whetzel's administrative style, festering a schism until 1922, when Whetzel stepped away from the headship (to be succeeded by Massey). It was

Korf's (1991) opinion: "Then there was Donald Reddick, a potato breeder, and internationally known pathologist and the purported ringleader of the revolt against Whetzel's chairmanship that rocked the department in the early 20's." Through it all, Reddick remained in place, rising from Assistant Professor to Associate Professor to Full Professor until his retirement in December 1950, five years before his death in Gainesville, Florida.

Stewart, S.S. '06

I can find no record of "S.S. Stewart '06" other than the listing by Kent (1979).

Ruth, Warren Albert (1884–19xx) '06

Another Hoosier, Warren Albert Ruth was born in Mishawaka, Indiana, in the very north of the state. His fellow graduate was another Prof. Thomas student, class of 1906, S.S. Stewart. After obtaining an M.A. in pomology from Wabash in 1909, Ruth was hired by the University of Illinois Agricultural Experiment Station (Urbana) where he received his Ph.D. in 1919 from the University. His fate through WW I is not known, but Ruth stayed on the staff of the Illinois Station and also became an Assistant Professor in Agriculture at the University. His later years could not be ascertained.

Barrus, Mortimer Franklin (1879–1962) '07

Born in Forestville, Chautauqua Co., NY, Mortimer (a.k.a. Mortier) Franklin Barrus was listed in the U.S. Census as still living with his mother at 21 years old. An older-than-usual graduate of Wabash in 1907, Barrus came to Cornell just when the Plant Pathology Department was established and before the time of "Industrial Fellowships." He obtained a Ph.D. degree in Plant Pathology, and remained at Wabash for the rest of his career as Professor of Plant Pathology and as Extension Professor of Plant Pathology, specializing in field crop diseases from beans to potatoes (Barrus 1954). Publications continued into the 1940s and 50s. In a historical summary of extension plant pathology (Jacobsen & al 2008): "The first officially appointed extension plant pathologists were R.E. Vaughan at Wisconsin and M.F. Barrus at Cornell in 1915. However, it should be pointed out that Dr. Barrus had already been appointed Assistant Professor of extension work on September 20, 1911 at the New York State College of Agriculture." Perhaps Barrus's most noticed publication was The Potato with fellow Cornellian, AW Gilbert in Plant Breeding, published by McGraw Hill as part of a pioneering series of such books. Korf's (1991) comment: "M.F. Barrus, a gentle, delightful man, had worked with diseases of beans, potato, and fruit." Barrus was an early President of the American Phytopathological Society in 1928.

Anderson, Harry Warren (1885–1971) '07.

Harry Warren Anderson was born in Ladoga, Indiana and buried in Crawfordsville. His brother, Paul, followed at Wabash, class of 1910. Harry remained at Wabash as an instructor from 1908–10, and after a brief sojourn at the University of Illinois, returned to Wabash as Rose Professor and Head of the Department of Botany, succeeding his mentor, Mason Thomas. In 1916, he returned to the University of Illinois and was Associate Professor of Pomology and later Professor of Plant Pathology. As late as 1956,

Harry Anderson published Diseases of fruit crops through McGraw Hill. Harry's son, Phillip W. Anderson, won the Nobel Prize in Physics in 1977.

Dorner, Herman Bernard (1878-1955) ex '08

Herman Bernard Dorner was born in Lafayette, Indiana, of parents who were prominent carnation breeders and ran a greenhouse. Unlike the others in this roster, Dorner earned his B.S. at Purdue University in 1900, and an M.S. in 1901. In 1905 he was a Botany Assistant at Purdue and an Assistant at Indiana State College, but in 1906–07 he became Assistant Professor of Botany at Wabash. In 1907, he co-authored A key to the genera of native forest trees and shrubs of Indiana. Author of several popular articles on flower growing (especially carnm 9-lo[p0ations), he was a founder of "Flowers by Wire," the florists' telegraph delivery. By 1911, Dorner was an Associate Professor in Floriculture at the University of Illinois and its Agricultural Experiment Station. Dorner retired in 1946 as Professor of Floriculture at Illinois.

Price, Earl '09

Unfortunately, essential data on Earl Price (Wabash 1909) are missing. Conflicting sources report: [1] 1915. Earl Price, Harrisburg, Illinois, county agent. [2] 1916 Earl Price, school teacher of agriculture in Valparaiso, Indiana. [3] 1964. "Dean" [of Agriculture] Earl Price of Oregon State, witness at House ([of US Representatives] Committee on Appropriations. Perhaps the first report is correct

Stewart, Vern Bonham (1888–1918) '09

Vern Bonham Stewart was another Hoosier born in Avilla, Indiana (see also Whetzel, Weimer). After graduation from Wabash he spent the summer supported by an "Industrial Fellowship" sponsored by the C.W. Stuart [nursery] Co. of Orleans, NY, after which he entered Cornell Plant Pathology, already with the title of Fellow. His Ph.D. was earned in 1913, and he joined the staff at the Cornell Agricultural Experiment Station. His thesis (and publication; Stewart 1913) was on the fire blight disease of nursery stock. He remained a frequent author of plant pathology papers and remained on the staff through June 1918. He accepted an appointment at the "Bureau of Plant Pathology" in Washington. In December 1918, in Newark, NJ, he died of pneumonia (probably a complication of the "Spanish flu"), leaving a wife and infant daughter (Reddick 1919).

Pegg, Ernest Cecil (1888–19xx) '09

Essential data are also missing for Ernest Cecil Pegg (Wabash 1909), winner of that year's Eastman Prize. Born in 1888 in Fountain City, Indiana, Pegg was interested in forestry as an undergraduate. In his senior year, Pegg and fellow student N.S. Thomas (Pegg & Thomas 1909) published in the Proceedings of the Indiana Academy of Science. Upon graduation he spent three months "timber estimating" in Tennessee before attending Yale Forestry School, graduating in 1911. After a year with the U.S. Forest Service at Jemez National Forest in New Mexico, he joined the one-man faculty at the University of Missouri Forestry School. He was immediately put in charge of establishing the "summer camp" in forestry. In 1919 he resigned his Missouri post, and the Department of Forestry was abolished a year later. At this point the trail peters out.

In 1912, Pegg was married in Crawfordsville, Indiana, to Ruth Amanda Hesler, daughter of Benton F. Hesler. Considering that Lex Hesler's tenure at Wabash ended in 1911, the match may not have been coincidental.

Fitzpatrick, Harry Morton (1886–1949) ex '09

Born in Greenwood, Indiana, Harry Morton Fitzpatrick attended high school in Crawfordsville where he became acquainted with Herbert Whetzel, then a student at Wabash. Fitzpatrick entered Wabash College, 1905, where Mason Thomas was his mentor. Aided by Thomas and Whetzel (by that time a graduate student at Cornell), Fitzpatrick transferred to Cornell in 1908 to become an assistant to George Atkinson (in Botany). He received his A.B. from Cornell in 1909 and continued on to graduate school as Assistant in Plant Pathology and later as Instructor. His Ph.D. was awarded by Cornell in 1913. By then Whetzel was Head of the new Plant Pathology Department and Fitzpatrick was immediately appointed Assistant Professor, with duties to teach mycology, which developed into a full-year course. Lex Hesler knew Fitzpatrick well, for they overlapped for some years at Cornell. Of Fitzpatrick, Hesler (1975) wrote: "Two characteristics of the man stood out in my memory: he was an unusual scholar and teacher; and he was a recluse."

According to Hesler: "Fitzpatrick was highly respected by other mycologists, but only a few knew him well. He was quiet, and often seemed dubious of the sincerity of some individuals. Through poor health and brooding over the suicide of a favorite son, Fitzpatrick himself took his own life in December 1949." Korf (1991) included reminiscences of Fitzpatrick (aka "Prof. Fitz"), who was Korf's major professor: "He was often considered morose, but in fact had a deep sense of humor, though he could often be put off. He was said to have been champion at pitching pennies in the hallways, a departmental pastime in which he is reputed to have relieved many a graduate student of his (her) horde of pennies." Also reputed to be competent on the tennis court, Fitzpatrick shared his energy in service appointments; he was one of the founders of the Mycological Society of America (1931) and its President in 1936. He was also its Historian and wrote of its early times (Fitzpatrick 1924).

Korf (1991): "On founding the Plant Pathology department Whetzel understandably sent all the plant pathology students down to the Arts College to take their mycology from Atkinson, but Atkinson's greater and greater preoccupation with the agarics led to a somewhat distorted course offering. When Harry M. Fitzpatrick, who while at Wabash had been thoroughly indoctrinated and encouraged by Whetzel, completed his doctorate under Atkinson in 1912, Whetzel installed him in the Plant Pathology department to teach mycology."

As mentioned by Petersen (2019) and others (e.g., Hesler 1975), there was bad blood between G.F. Atkinson and Curtis Gates Lloyd. In 1920, Lloyd came to Ithaca to visit his nephew, but Atkinson shunned him. As told by Korf (1991): "Fitzpatrick heard that Lloyd was in town, contacted him, and invited Lloyd to lecture to his students and accompany them on a number of field trips in the area. Fitzpatrick's kindnesses, and for Lloyd perhaps unexpected 'acceptance' in academia, led Lloyd to purchase, unbeknownst to anyone in the Department, three major collecting grounds, which he

then gave to the University. These are now called the Lloyd-Cornell Preserves…to this day some of the best areas in which to collect fungi within a 50 km radius of Ithaca."

Taylor, Clarence Egbert (1886–1971) '10

Clarence Egbert Taylor was born in Anthony, Kansas, but the family moved to South Bend, Indiana, when Taylor was still very young. After graduation from South Bend High School, Clarence entered Wabash College and subsequently Yale School of Forestry, receiving a Master's Degree in 1912. That August, Taylor was in the U.S. Forest Service at Plumas National Forest, northeastern California, headquartered in Quincy. That forest included Mt. Shasta and the northern terminus of the Sierra chain. In 1913 he was loaned to the Pennsylvania Chestnut Blight Commission, but soon was transferred to Pine Mountain National Forest in west-central Georgia (established 1906). By 1921–22, Taylor was listed as "forest examiner" at Cochetopah National Forest, Colorado. All three of these national forests were established during the presidency of Theodore Roosevelt as part of his conservation program. Further data on Taylor are missing.

Anderson, Paul Johnson (1884–1971) '10

A product of Lodoga, Indiana, Paul Johnson Anderson (Wabash 1910), younger brother to Harry Anderson (q.v.) was appointed to one of Whetzel's "Industrial Fellowships" for 1910–11 and was awarded a Ph.D. by Cornell University Plant Pathology in 1913. His thesis was The morphology and life history of the chestnut blight fungus. His early career was at the Massachusetts Agricultural Experiment station (of Massachusetts Agricultural College) but by 1926 he was on staff at the Connecticut Agricultural Experiment Station, headquartered in new Haven. He became Pathologist in Charge, Connecticut Tobacco Experiment Station (at Windsor, CT) where he stayed until retirement to Florida. Perhaps tellingly, Anderson is buried in Amherst, Massachusetts.

Davis, Elmer E. (dates unknown)'10

Elmer E. Davis spent much of his career at the American Type Culture Collection and was publishing on fungi as late as 1976.

Rankin, William Howard (1888–19xx) '10

William Howard Rankin proceeded to Cornell Plant Pathology for a Ph.D. in 1912. By 1912 he was publishing on chestnut canker disease and in 1918 wrote A Manual of Tree Diseases, the second book in a series on tree pathology from MacMillan Co. In the preface, Rankin thanked several Cornell colleagues among whom were other Wabash graduates. The book was popular enough to see a second printing in 1923. In 1920, in a popular Cornell journal there appeared the following: "Dr. William H. Rankin, for the last five years assistant professor of plant pathology, has been appointed officer in charge of the field Laboratory of Plant Pathology of the Canadian Department of Agriculture, with headquarters at St. Catherine, Ontario, and has entered upon his duties." Two histories of Canadian plant pathology and mycology (Estey 1994a,b) cite Rankin as one of a few forest pathologists dealing with Canadian fir. By 1925, Rankin was back at Cornell, but this time at the Geneva Experiment Station. That year, Rankin collaborated

with other Cornell colleagues on a second edition of Laboratory outlines in plant pathology ("Second edition, completely revised and rewritten"). In 1933, Rankin was second author on a paper on raspberry growing in New York State.

Rees, H.L. (dates unknown) '10

H.L. Rees was one of several Thomas students in Thomas's later time at Wabash. Oddly, Rees was reported at Cornell University Plant Pathology in 1910, where he replaced C.N. Jenson as an assistant, but later in 1910 he was Plant Pathologist at the Oregon State College Agricultural Experiment Station, Corvallis, where he wrote the annual report for the Department of Plant Pathology. A note in Mycologia in 1913: "Mr. H.L. Rees has moved to the Western Washington Experiment Station, Puyallup." There he published 11 papers in seven years (1913–20) but at that point his biographic material runs out. Much essential information is missing.

Schramm, Jacob Richard (1885–1976) '10

A Hoosier from Hancock Co., Indiana, Jacob ("Jake") Richard Schramm not only graduated from Wabash but continued his interaction with Thomas and other Wabash academics for years. Schramm's botanical career started at Washington University (St. Louis) where he earned a Ph.D. in 1913. For a decade, he taught at Cornell in the Botany Department (not Plant Pathology). As an independent investigator during these years Schramm spent summers at the Marine Biology Station at Woods Hole, Massachusetts, where Mason Thomas and G.T. Moore also worked. Thomas brought later students with him, always on some sort of grant arranged by Schramm (or Herbert Whetzel; q.v.), among whom was Lex Hesler. G.T. Moore moved to St. Louis to become Professor of Botany at George Washington University. Moore was so impressed by Schramm that he had him appointed as a 3-year Lackland Fellow at George Washington, and when Moore took directorship of the Missouri Botanical Garden, Schramm became his chief assistant. His later address was St. Louis Botanical Garden and Washington University (St. Louis), but for the rest of his career he was Professor of Botany at the University of Pennsylvania (1937–55) and also Director of the Morris Arboretum (1939–54). He was one of the founders of Botanical Abstracts and served with G.T. Moore on its Editorial Board. In retirement, Schramm was a Research Scholar at the University of Indiana.

Hesler, Lexemuel Ray (1888–1979) '11

Of the considerable roster of Wabash graduates covered here, Lexemuel ("Lex") Ray Hesler is the only worker for whom too much information is presently available. Born in Veedersburg, Indiana, in 1907 the Hesler family moved to Crawfordsville, Indiana, coincident with Lex's entrance into Wabash. Among his new college friends were Jacob Schramm (q.v.) and Harry and Paul Anderson (q.v.) all destined for graduate work proposed by Mason Thomas, their mentor. Even before graduation from Wabash, Hesler worked on one of Whetzel's "Industrial Fellowships," this one from apple growers in New York State. The fellowship was to be extended through his graduate school career. Upon receipt of his Cornell Ph.D. in 1914, Hesler was retained on the faculty until 1919, when he moved to the University of Tennessee as Professor of Botany and Department Head. It was difficult to make a living on the wages of nine-month appointments, and

for more than a decade of summers Hesler worked for the U.S.D.A. in wheat-rust eradication survey and potato disease survey, both in the Washington office and New England, Wyoming, the Gulf states. and Mayaguez, Puerto Rico.

In 1934, a disastrous fire incinerated the University of Tennessee botany department physical plant, including an 8000-specimen fungal herbarium, a large reprint collection, notes and manuscripts, all largely plant pathological. In the aftermath, Hesler turned his interest to the abundant fleshy fungi in the Great Smoky Mountains and later in 1934, he was appointed Dean of the College of Liberal Arts. Just before and after retirement in 1958, several major North American floristic monographs of agaric genera were published, mostly co-authored with Alexander H. Smith, the reigning North American agaric authority of the time.

Jennison, Harry Milliken (1888–1940) '11

Harry Milliken Jennison, from Worcester, Massachusetts, received his A.B. from Massachusetts State College at Amherst (class of 1908) but his A.M. from Wabash College (class of 1911). Like Jake Schramm before him, Jennison studied at Washington University, St. Louis, earning a Ph.D. in 1922. Art Stupka (1905–99) wrote of Jennison: "Harry Milliken Jennison was associated with the University of Tennessee from 1922 until his death in 1940. He was given a two-years' leave of absence from his teaching duties in the Department of Botany, beginning in 1935, during which time he served in the Great Smoky Mountains National Park as a wildlife technician under the Civilian Conservation Corps; his chief duties were the collection, identification, and preparation of plant specimens."

"During the summers of 1938 and 1939 Jennison served in the Park in the capacity of ranger-naturalist. In 1938 he prepared A classified list of the trees of Great Smoky Mountains National Park." Jennison's association with Tennessee included the disastrous fire of 1934, which destroyed the department's entire space, including the herbarium.

Osner, George Adin (1888–1964) '11

Like several others in this roster of "Wabash Boys," data on George Adin Osner is sparse after his early career. Born in Madison, Indiana, on the Ohio River, Osner's time at Wabash was concurrent with that of Hesler and Jennison. Moreover, like Hesler, in 1911, Osner was bound for Cornell Plant Pathology on one of Whetzel's "Industrial Fellowships" which actually extended through 1913. At Cornell he was listed under plant pathology, agricultural chemistry and economic entomology with professors Whetzel, Cavanaugh, and Herrick. The next year, his advisors changed to Reddick, Bennett, and Herrick. In 1915 he received his Ph.D. from Cornell. His thesis was "Leaf smut of timothy," published as Experiment Station Bulletin 381. But another event also required his attention; his marriage to Bess Joy ("Beanie") Whetzel, Herbert Whetzel's sister. Perhaps this caused the change in advisors. The following year (1916) another significant paper was published, "Some effects of oxygen and carbon dioxide on nitrification and ammonification in soils" as Experiment Station Bulletin 384, co-authored by Louis Melville Massey (q.v.), a fellow Wabash grad. Also in 1916, Osner

pubished "Additions to the list of plant diseases of economic importance in Indiana," this time in the Proceedings of the Indiana Academy of Science. Osner was on staff as Assistant Botanist at the Purdue University Agricultural Experiment Station. He remained on staff there until at least 1919, but from that year, further data seems missing until late in his life. An unreliable entry reports his death in Delano, Kern Co., California, in 1964.

Babcock, Duane Cook (1887–1961) '12

Duane Cook Babcock graduated from Wabash together with J.H. Muncie, L.M. Massey, C.C. Tomas, and J.L. Weimer. Aiming for Cornell, he was hired under a Whetzel "Industrial Fellowship" that summer, but there is no record of his enrollment at Cornell. Instead, he was listed on staff at the Ohio State Agricultural Experiment Station at Wooster in 1913, with the title Assistant Botanist and Agent of the Laboratory of Forest Pathology. There he was a leader in organizing field studies of Chestnut bark disease. Babcock published "Diseases of forest and shade trees" in the Ohio Agricultural Experimental Station Monthly Bulletin and was on staff when L.R. Hesler was an Associate Plant Pathologist there in the summers of 1925–28. In 1940, Babcock was listed in a bibliography of American forestry, and apparently remained with the station until retirement, and in Wooster, Ohio, until death in 1961.

Massey, Louis Melville (1890–1969) '12

Born in Lima, Ohio, Louis Melville Massey obtained his Ph.D. in Plant Pathology from Cornell in 1916. Massey's thesis, "The hard rot disease of gladiolus" was published as the Experiment Station Bulletin 380. As did others, he stayed at Cornell Plant Pathology, where he taught the general courses for Herbert Whetzel. When Whetzel stepped aside from administrative duties in 1922, Massy became Acting Head, and the following year, Department Head. Several sabbatical leaves were spent at the Boyce Thompson Institute near New York City, and later at the University of California at Berkeley. He retained the department headship until 1950, and formally retired in 1958, after a lengthy career at Cornell. In his memorial: "The least recognized but probably the greatest contribution to his field and his institution was his ability as an administrator. He 'took over' the administrative duties at a time when a small staff was split and discouraged. He directed a reunification and vigorous development, the occupation of new and modern quarters within a few years, and 'turned over' a staff tripled in size and as harmonious in operation as could be expected. He was respected for his honesty, his judgment, and his keen vision."

Muncie, Jay H. (dates unknown) '12.

In 1912–13 Jay H. Muncie held an "Industrial Fellowship" in Plant Pathology, Cornell. Without completing an advanced degree at Cornell, Muncie became an Assistant in Plant Pathology at the Michigan State Experiment Station in East Lansing. Several authored papers appeared as publications of the Experiment Station. He remained on staff until the early 1920s when he moved to Iowa. Muncie received a PhD from Iowa State University in 1926, with his thesis "A study of crown gall caused by *Bacterium tumefaciens* on rosaceous hosts." Again, his research was published, including

in American Journal of Botany. By 1930, Muncie returned to Michigan State where he was on faculty as Research Associate and Extension Plant Pathologist.

Thomas, Cecil Calvert (1886–1936) '12

Cecil Calvert Thomas was one of many students handled by Mason Thomas in his last years. Thomas remained to receive a Master's degree in 1913, then proceeded to Cornell where he was listed as a graduate student in 1913–14 and as an Instructor in Botany in 1915 (not Plant Pathology), but there is no evidence that he obtained the Ph.D. Nonetheless, he was employed by the U.S.D.A. Bureau of Plant Industry and wrote a bulletin on the Chinese Jujube (Thomas 1924), comprehensive enough to be reprinted in the 21st century. His own title at that time was Assistant Plant Instructor, Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry,

Thomas was known for his expertise in propagation of trees from cuttings.

Weimer, James LeRoy (dates unknown) '12

Born and raised in Avilla, Indiana, James LeRoy Weimer attended Cornell thereafter. Listed as a graduate student, he was supported on one of Whetzel's "Industrial Fellowships." His Ph.D. thesis (Cornell 1917) was "Three cedar rust fungi their life histories and the diseases they produce," published as Cornell Experiment Station Bulletin 390. Upon graduation, he joined the USDA's Bureau of Plant Industry, where he remained throughout his professional career. His title was Senior Pathologist, Division of Forage Crops and Diseases. Weimer's publications continued into the 1950s.

Burkholder, Walter Hagemeyer (1891–1983) '13

Walter Hagemeyer ("Burkie") Burkholder was born in Crawfordsville, Indiana, so perhaps it was natural that he attended Wabash College (A.B., class of 1913) and succumbed to the mentorship of Mason Thomas. From Wabash he attended Cornell under one of Whetzel's "Industrial Fellowships" and was awarded the Ph.D. in 1917. Upon graduation he was appointed progressively as Assistant, Assistant Professor, and Professor of Plant Pathology. His pioneering work on bacterial taxonomy was adopted in Bergey's manual for some years. His geniality was celebrated in his "official" eulogy: "Burkie was an avid reader of poetry and fiction and especially enjoyed light opera. He was a connoisseur of fine food and liquor, whose subtle delights he happily introduced to others" (Rochow & al. 1983).

Chupp, Charles David (1886–1967) '13

Charles David Chupp was typical of the rough-hewn Hoosiers of his time. Born in Illinois, the family moved to Indiana and Chupp spent his young life with his older brother in Edinburg, Indiana (Boothroyd 1982). In the midst of his Wabash years, Chupp dropped out for three years, working as a school teacher of numerous subjects. Boothroyd (1982) related Chupp's story: "As Chupp recalls, 'I had planned to specialize in English, but regularly got D in that subject while it was easy to get an A in Botany under the teaching of the famous Professor M.B. Thomas. On his deathbed he willed me to Cornell in 1912. Luckily Professor Whetzel, Head of the Plant Pathology Department accepted me.'" Cornell granted him a Ph.D. in 1916, and Chupp returned to Wabash as

Acting Professor of Botany (Thomas had died in 1912), but after one year he migrated back to Cornell. The passage of the Smith-Lever Act in 1914, with funding for the states to conduct extension work, and earlier organization of the Farm Bureau to appoint county agents, laid the groundwork for rapid development of extension activities in the College of Agriculture. Chupp, under the tutelage of M.F. Barrus, then himself leader in the vegetable disease area, entered vigorously into this world of extension and soon became known as the expert. Farmers all over the state (and in fact many people outside the United States) became his friends and admirers. Chupp soon participated with Barrus in developing Plant Pathology extension until his retirement in 1954. Korf's (1991) comment: Chupp "was one of the most beloved of the professors, always cheery, filled with fun, a vegetable pathologist with lifelong interest in the taxonomy of the genus *Cercospora* ..."

Gibson, C.B. (dates unknown) '14

I can find no information on C.B. Gibson, Wabash class of 1914. Mason Tomas died in 1912, presumably in Gibson's sophomore year, and Gibson's post-graduation life remains undocumented. A careful check might reveal Kent's (1975) reference to Gibson as faulty.

Pickler, William Eugene (1892–1989) '14

Born in New Albany, Indiana, but early educated in Louisville, Kentucky, William Eugene Pickler moved on to the University of Illinois where he was given a series of fellowships starting at $300 but later raised to $600 for 10-month contracts. He earned a Ph.D. in botany (plant physiology) from the University of Illinois in 1918. His thesis was "Water content and temperature as factors influencing diastase formation in the barley-grain." He was appointed to the Bureau of Plant Industry where his duties were primarily with White pine blister rust eradication. An obituary published in 1989 indicates that he was a Veteran of World War I (unlikely given his academic achievements during the war years) and employed by the Louisville Water Department for 40 years prior to his retirement.

Wann, Frank Burkett (1892–1954) '14

Born in Warsaw, Indiana, Frank Burkett Wann was handicapped from birth (no more specific data found). Though circumstances are unclear, he was enrolled in the Henry Shaw School of Botany in St. Louis and there taught general botany with Jacob Schramm (q.v.) under the leadership of George Moore (q.v.). Seeking additional formal education, he returned to his home state and enrolled in Wabash College, receiving an A.B. in 1914. His time there spanned the death of Mason Thomas. In 1915 he was reported as Teaching Fellow in Botany back at the Shaw School. By 1919 he was reported by Sigma Xi Cornell chapter as Fellow in Botany. Wann's Ph.D. thesis was

"The fixation of free nitrogen by green plants." Wann stayed on at Cornell as an Instructor (1921–23) and was awarded a three-year fellowship by the National Research Council. In 1926 he departed Cornell for an appointment as Associate Professor of Plant Physiology at Utah State College (Logan) and its Agricultural Experiment Station. His research investigated mineral deficiencies in fruit trees and vegetable crops. He became department head of Botany and Plant Pathology in 1952 but lived less than two years thereafter. A quote from his obituary: "Through his classes, many young men at Utah Stare became interested in botany. His encouragement led many students to go away to the leading universities of the world and to become renowned authorities in plant science;" a statement reminiscent of Wann's mentor, Mason Thomas back at Wabash.

Appendix 5.

"Industrial Fellowship" students

Excerpted from Whetzel, H.H. 1945. The history of industrial fellowships in the Department of Plant Pathology at Cornell University. Agricultural History 19(2): 99–104.

* = Wabash graduate. [Shared fellowships indicated by numerical superscripts.]

Name	Year(s)	Funds ($)
Wallace, Ernest	1909–10	1500/yr
*Stewart, V.B.	1909–10	750/yr
[1, 2, 3]Blodgett, F.M.	1910–11	3,000
[1, 2]Jensen, C.N.	1910–11	4,000
[3]Sherbakoff, C.D.	1912–13	
[3]Faulwetter, F.C.	1912–13	
[3]Jagger, I.C.	1911–12	750
	1912–13	750
*Rankin, W.H.	1910–11, '11–12	750/yr
[5]*Anderson, P.J.	1910–11	750/yr
[7]*Hesler, L.R.	1911–12	750
	1912–13	375
[4, 7]Brausher, R.W.	1911, 1912	
[4, 7]*Osner, G.	1911, '12–13,	
	1913–15	[4] 2000
		[7] 1415
	1914	1000
	1915	891
Jehle. R.A.	1911	730
*Stewart, V.B.	1911–12	2000
	1913–14	2000
[5]Wallace, E.	1911–12	2000
*Muncie, J.H.	1912–13	2000
*Burkholder, W.H.	1912–13, 1915	
[6]Crittenden, C.G.	1913–14, '14–15	2176
Honey, E.E.	1917	487
Mix, A.J.	1912–13	1000
	1913–14	915
*Weimer, J.L.	1912	940
Slocum, C.L.	1914	1000
Dye, H.W.	1917–19	750/yr
Newhall, A.G.	1920–22	1000/yr
Gaines, J.G.	1925–26; '26–27	1000/yr
	1827–30	1250/yr
Harrison, A.L.	1930–31	583
[0]Felix, E.L.	1924–25; '25–26	1000/yr
[10]Cook, H.T.	1926–27	?
Vogel, I.H.	1919	1000
White, R.P.	1919–20; '20–21	1000/yr

Name	Year(s)	Funds ($)
Gratz, L.O.	1920-21; '21–22	1000/yr
[8]Boyd, O.C.	1920	1000
Fernow, K.H.	1920–21; '21–23	1000/yr
Schlatter, I.P.	1920–21	4000
[8, 9]Fitch, H.W.	1921–22; '22–23	4000/yr
[9]Pierstoff, A.L.	1923–24	4000
Newlands, R.E.	1925–26	4125
Kightlinger, C.V.	1924–25; '25–26	1000/yr
[1]Wiant, J.S.	1924–25;'25–26	10009/yr
	1926–27; '27–28	1250/yr
Burrell, A.B.	1924–26	?
Townsend, G.R.	1927–28, '28–29	1000/yr
Cook, H.T.	1928–29, '29–30	1250/yr
Stuart, W.W.	1930–31, '31–32	1000/yr
	1932–33	1250
Small, C.G.	1928–29, '29–30	1500/yr
	1930–31, '31–32, '32–33	1750/ yr
Erickson, E.T.	1928	1000
Meyer, L.J.	1929–30	1250
Parsons, B.	1930–31, '31–32, '32–33	1250/yr
Pirone, P.P.	1929–30, '30–31	1200/yr
	1931–32, '32–33	1450/yr
Richards, M.C.	1933–34, '34 –35	1200/yr
	1935–36, '36–37, '37–38	1450/yr
Cannon, O.S.	1938	1650
	1939–40	1600
	1940–41	1500
Lyle, E.W	1931–32, '32–33	1450/yr
	1933–34, '34–35, '35–36	1550/yr
McClellan, W.D.	1937–38, '38–39, '39–40	1000/yr
Linn, M.B./ Cochran, V.W.	1941, 1942 (summers)	100/summer
Hyre, R.A.	1931–32, '32–33, '33–34, '34–35	1500/yr
Harrison, A.L.	1932–33, '33–34	1500/yr
	1934–35, '35–36	1600/yr

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Craterellus atrobrunneolus sp. nov. from southwestern China

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Abstract—A new ectomycorrhizal fungus from southwestern China, *Craterellus atrobrunneolus*, is proposed as supported by morphological and phylogenetic analyses. The basidiocarps are characterized by a dark brown to brownish gray coloration, convex to plano-convex pileus with an umbilicate but not perforate center, smooth to slightly folded gray to cretaceous hymenophore, absence of clamp connections in all tissues, narrow basidia with 2–6 sterigmata, and broadly ellipsoid to subglobose basidiospores. Maximum likelihood and Bayesian sequence analyses of the ITS + nrLSU DNA regions confirm the phylogenetic position of the new species. Illustrations accompany the technical description and comparisons of *C. atrobrunneolus* and closely related species.

Key words—*Cantharellales*, *Hydnaceae*, taxonomy

Introduction

Craterellus Pers. is typified by the species *C. cornucopioides* (L.) Pers. (Persoon 1825). The genus, characterized by funnel-shaped fruiting bodies with a hollow stipe that may also be highly reduced (Petersen 1979), is closely related to *Cantharellus* Adans. ex Fr. from which it is distinguished mainly by the absence of clamp connections (Corner 1957, 1966; Bigelow 1978). However, some species that lack clamp connections have been also included

in *Cantharellus* (Yomyart & al. 2012; Wilson & al. 2012; Buyck & al. 2014; Bijeesh & al. 2018). *Craterellus* was previously classified in *Cantharellaceae* (*Cantharellales*) (Wilson & al. 2012; Henkel & al. 2014), but Hibbett & al. (2014) now indicate that *Cantharellaceae, Hydnaceae, Clavulinaceae,* and *Sistotremataceae* are synonymous, and *Hydnaceae* has priority as the correct name of the combined family. As ectomycorrhizal fungi, *Craterellus* species are symbiotic with canopy trees of the genera like *Aldina*, *Castanopsis*, *Cedrus*, *Cyclobalanopsis*, *Dicymbe*, *Hopea*, *Pakaraimaea*, *Pinus*, *Quercus*, and *Schima* (Matheny & al. 2010, Smith & al. 2011, Kumari & al. 2012, Wilson & al. 2012, Buyck & al. 2014, Henkel & al. 2014, Kour & al. 2015, Bijeesh & al. 2018, Zhong & al. 2018).

A total of 154 names have been recorded in this genus, and 76 species are currently accepted (http://www.indexfungorum.org). Most species are edible and often colorful (Zhong & al. 2018), although ten or so species are dark gray, dark brown, or black in color (Persoon 1825; Peck 1878; Burt 1914; Smith 1968; Petersen 1969, 1975; Wilson & al. 2012; Yomyart & al. 2012; Bijeesh & al. 2018). Most *Craterellus* species have been described from South America (Wilson & al. 2012, Henkel & al. 2014) and North America (Dahlman & al. 2000, Dunham & al. 2003, Porter & al. 2008, Wright & al. 2009, Matheny & al. 2010, Raja & al. 2017) plus several from Europe (Dahlman & al. 2000, Harrington & Mitchell 2002, Tibuhwa & al. 2012, Osmundson & al. 2013) and about ten species from Asia (Massee 1906, Bresadola 1913, Corner 1966, Kumari & al. 2012, Hembrom & al. 2017, Das & al. 2017, Bijeesh & al. 2018, Zhong & al. 2018). Only two species (*C. aureus* Berk. & M.A. Curtis and *C. luteus* T.H. Li & X.R. Zhong) have been originally described from China (Zhong & al. 2018).

During the investigation on macrofungi in southwestern China, a dark *Craterellus* species was collected from an angiosperm forest in Shizong County, Yunnan Province. We describe it as a new species, based on morphological characters and molecular analyses.

Materials & methods

Morphological studies

Specimens are deposited at the herbarium of Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China (IFP). Microscopic procedures followed Lu & al. (2018). Microscopic drawings were made with the aid of a drawing tube. Microscopic studies used sections mounted in Cotton Blue (CB): 0.1 mg aniline blue dissolved in 60 g pure lactic acid; CB+/– = cyanophilous/acyanophilous. Amyloid and dextrinoid reactions were tested in Melzer's reagent (IKI): 1.5 g KI (potassium

Table 1. *Craterellus* species, specimens, and sequences used in the phylogenetic analyses, with a *Hydnum ellipsosporum* outgroup. Type materials are annotated with [T].

Species	ITS	nrLSU	Voucher	Locality
C. albostrigosus	–	MG593194	CAL 1624 [T]	India
C. atratoides	JQ915093	JQ915119	MCA1313	Guyana
	JQ915103	JQ915129	TH8473	Guyana
	JQ915111	NG042660	TH9232 [T]	Guyana
C. atratus	JQ915092	JQ915118	MCA1070	Guyana
	JQ915100	JQ915126	MCA990	Guyana
	JQ915107	JQ915133	TH9203	Guyana
C. atrobrunneolus	**MN902353**	**MN894058**	**IFP 019359 [T]**	**China**
C. caeruleofuscus	MH558300	MH558300	TENN 073179	USA
C. cinereofimbriatus	JQ915104	JQ915130	TH8999	Guyana
	JQ915105	JQ915131	TH9075 [T]	Guyana
	JQ915112	JQ915138	TH9264	Guyana
C. cornucopioides	–	AF105298	UPSF-11800	USA
	–	AF105299	UPSF-11801	USA
	–	AF105301	HbO-53302	Norway
C. excelsus	JQ915102	JQ915128	TH8235 [T]	Guyana
C. ignicolor	–	AF105314	UPSF-11794	USA
C. indicus	NR119831	NG060387	PUN 3884 [T]	India
C. inusitatus	–	MG593195	CAL 1625 [T]	India
C. luteus	MG727896	MG701171	GDGM48105 [T]	China
	MG727897	MG727898	GDGM46432	China
C. lutescens	–	AF105302	UPSF-11789	Sweden
	–	AF105303	UPSF-11790	Sweden
	–	AF105304	UPSF-11791	Spain
C. odoratus	–	AF105306	UPSF-11799	USA
C. olivaceoluteus	JQ915098	JQ915124	MCA3186	Guyana
	JQ915109	JQ915135	TH9205 [T]	Guyana
C. parvogriseus	MF421099	MF421098	CAL 1533 [T]	India
C. pleurotoides	JQ915097	JQ915123	MCA3124	Guyana
	JQ915110	JQ915136	TH9220	Guyana
	KT339208	KT339208	TH8877	Guyana
C. shoreae	–	KY290585	CAL 1396 [T]	India
Craterellus sp.	–	KM484695	BB 09.079	India
	JQ915091	JQ915117	AWW263	Malaysia
	KJ786699	KJ786611	G3211	Guyana
	KJ786682	KJ786577	G2070	Guyana
C. strigosus	JQ915094	JQ915120	MCA1750	Guyana
	JQ915108	JQ915134	TH9204 [T]	Guyana
C. tubaeformis	EU057081	EU057081	ECUBC19	Canada
	KP454008	KP454008	UBC F28404	Canada
	DQ474413	–	SWUBC511	Canada
Uncult. ECM	AB251810	–	Pdmt4	Japan
Hydnum ellipsosporum	KX086215	KX086217	FD3281	Switzerland

iodide), 0.5 g I (crystalline iodine), 22 g chloral hydrate, aq. dest. 20 ml; IKI– = neither amyloid nor dextrinoid reaction. 5% KOH was used as a mountant. Sections were studied at magnifications up to ×1000 using a Nikon Eclipse E600 microscope with phase contrast illumination; dimensions were estimated subjectively with an accuracy of 0.1 µm. Surfaces of the basidiospores and basidia were observed with a Phenom Prox scanning electron microscope (ESEM) at an accelerating voltage of 10 kV. For spore measurements, the apiculus was excluded. In presenting the spore size ranges, 5 % of the measurements at each end of the range are given in parentheses. The following abbreviations are used in the text: L = mean spore length; W = mean spore width; Q = variation in the ratios of L/W between specimens studied; n = number of spores measured from a given number of specimens. Terminology for descriptive terms follows Vellinga (1988) and special color terms are from Kornerup & Wanscher (1978).

Molecular procedures and phylogenetic analyses

Phire Plant Direct PCR Kit procedures were used to extract total genomic DNA from the basidiocarps. Polymerase chain reactions (PCR) were performed on a Bio-Rad T100TM Thermal cycler. The DNA was amplified in a 30 µl reaction mixture comprising 0.9 µl template DNA, 15 µl of 2× Phire Plant PCR buffer, 1.5 µl of each primer, 0.6 µl Phire HS II DNA Polymerase, and 10.5 µl ddH2O (double distilled water). The nuc rDNA ITS1-5.8S-ITS2 region (ITS) was amplified with the primers ITS1-F (5′CTTGGTCATTTAGAGGAAGTAA3′) and ITS4 (5′TCCTCCGCTTATTGATATGC3′) (White & al. 1990). The 28S nuclear rDNA region was amplified with the primers LROR (5′ACCCGCTGAACTTAAGC3′) and LR5 (5′TTAAAAAGCTCGTAGTTGAAC3′) (Vilgalys & Hester 1990). The PCR thermal cycling program condition was set as follows: initial denaturation at 95 °C for 5 min; followed by 35 cycles at 95 °C for 30 s, either 57.2 °C (for ITS1-F/ITS4) or 52 °C (for LROR/LR5) for 30 s and 72 °C for 30 s; and a final extension at 72 °C for 7 min. PCR amplification was confirmed on 1% agarose electrophoresis gels stained with ethidium bromide. DNA sequencing was performed at the Beijing Genomics Institute (BGI), and the newly generated sequences were submitted to GenBank.

The sequences were processed in GenBank (http://www.ncbi.nlm.gov) using the BLAST option and downloaded (Table 1). The ITS and nrLSU dataset includes the new species and other closely related species. Sequences were aligned using Clustal X (Thompson & al. 1997). Maximum likelihood (ML) analysis was performed in RAxML v8.2.4 with GTR + I + G model (Stamatakis 2014). Bayesian analysis with MrBayes 3.2.4 (Ronquist & Huelsenbeck 2003) implementing the Markov Chain Monte Carlo (MCMC) technique and parameters predetermined with MrModelTest2.3 (Posada & Crandall 1998; Nylander 2004) were performed and the parameters in MrBayes were set as follows: lset nst = 6, rates = invgamma. Four simultaneous Markov chains were run starting from random trees and keeping one tree every 100th generation until the average standard deviation of split frequencies was <0.01. The value of burn-in was set to discard 25% of trees when calculating the

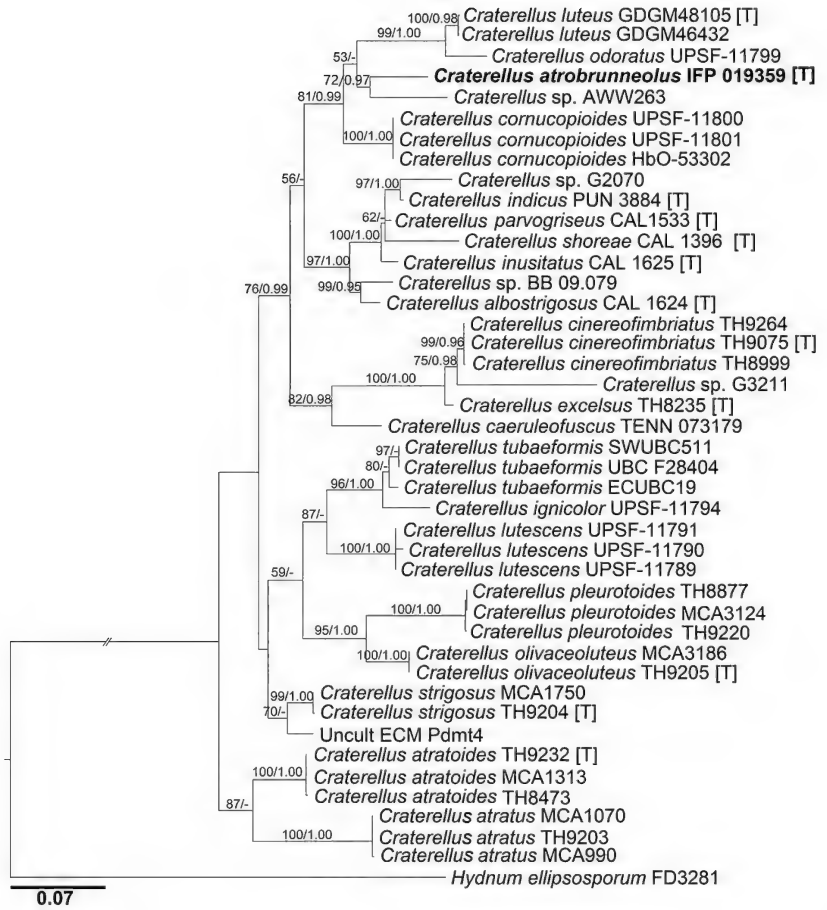

FIGURE 1. Maximum likelihood tree illustrating the phylogeny of *Craterellus atrobrunneolus* and related taxa based on ITS + nrLSU sequences dataset. The type materials are annotated with [T]. Branches are labeled with maximum likelihood bootstrap support >50% and Bayesian posterior probabilities >0.95.

posterior probabilities. Bayesian posterior probabilities were obtained from the 50% majority rule consensus of the trees kept.

Phylogenetic results

The ITS + nrLSU dataset included 43 sequenced specimens, representing our new species, 24 other identified or putative *Craterellus* species, and the outgroup

Hydnum ellipsosporum Ostrow & Beenken. Bayesian analysis ran 2,000,000 generations and produced an average standard deviation of split frequencies = 0.006070. A similar topology (Fig. 1) was generated when the same dataset and alignment were analyzed using ML. In the phylogenetic tree, our new holotype specimen was closely related to an unidentified *Craterellus* species (AWW263) with moderate support and joined with the clade comprising *Craterellus luteus* and *C. odoratus* (Schwein.) Fr. with moderate support.

Taxonomy

Craterellus atrobrunneolus T. Cao & H.S. Yuan, **sp. nov.** Figs 2–4

MB 833932

Differs from *Craterellus strigosus* by its larger basidiocarps, smaller basidiospores, and absence of clamp connections on hyphae in all tissues.

Type: China. Yunnan Province, Shizong County, Junzishan Mt., on the ground in angiosperm forest, 8 Aug 2019, Yuan 13878 (**Holotype**, IFP 019359; GenBank MN894058, MN902353).

Etymology: *atrobrunneolus*, referring to the dark brown to brownish gray basidiocarps.

Basidiocarps annual, solitary to concrescent, soft and leathery when fresh, becoming friable and light in weight upon drying. Pileus thin, 1.5–3.0 cm in diam, when young infundibuliform, in age becoming convex to plano-convex with a shallow depression at center, umbilicate (not perforate). Pileal surface dark brown (6F7/7F6/8F6) to almost black when moist, drying become brownish gray (6E3/6E2), subglabrous, regularly wrinkled to sparsely veined. Pileal margin slightly incurved, wavy, irregularly folded, crenate or sometimes incised. Hymenophore bluish grey (23B2), smooth to slightly folded and down to the stipe. Pileal context very thin, grayish (1E1), leathery. Stipe confluent with pileus, 2.5–5.0 cm long and 0.3–1.5 cm diam, leathery or fleshy when fresh, soft corky upon drying, concolorous with the pileal surface; hollow, irregularly pitted, usually curved and eccentric; smooth to finely rugulose, not thickening substantially, 0.1–0.3 mm thick in section; stipe base somewhat bulbous. Odor mild; taste not distinctive.

Basidiospores broadly ellipsoid to subglobose, yellowish in 5% KOH, with granular contents; wall 0.5 µm thick; apiculus 0.5–1.0 µm long; CB+, IKI–, (6.2–)6.5–7.8(–8.0) × (4.2–)4.5–6.0(–6.2) µm, L_m = 7.38 µm, W_m = 5.47 µm, Q = 1.35–1.52 (n = 60/2). Basidia 45.5–70 × 5.2–8.5 µm long, narrow, subcylindric, subclavate to clavate, with large guttules or finely granulose contents, hyaline to yellowish in 5% KOH; 2–6 sterigmata, 3.5–6.0 µm long. Basidioles 40.5–65 × 5.0–8.0 µm, abundant, cylindrical to subclavate,

FIGURE 2. *Craterellus atrobrunneolus* (holotype, IFP 019359). Basidiocarps.

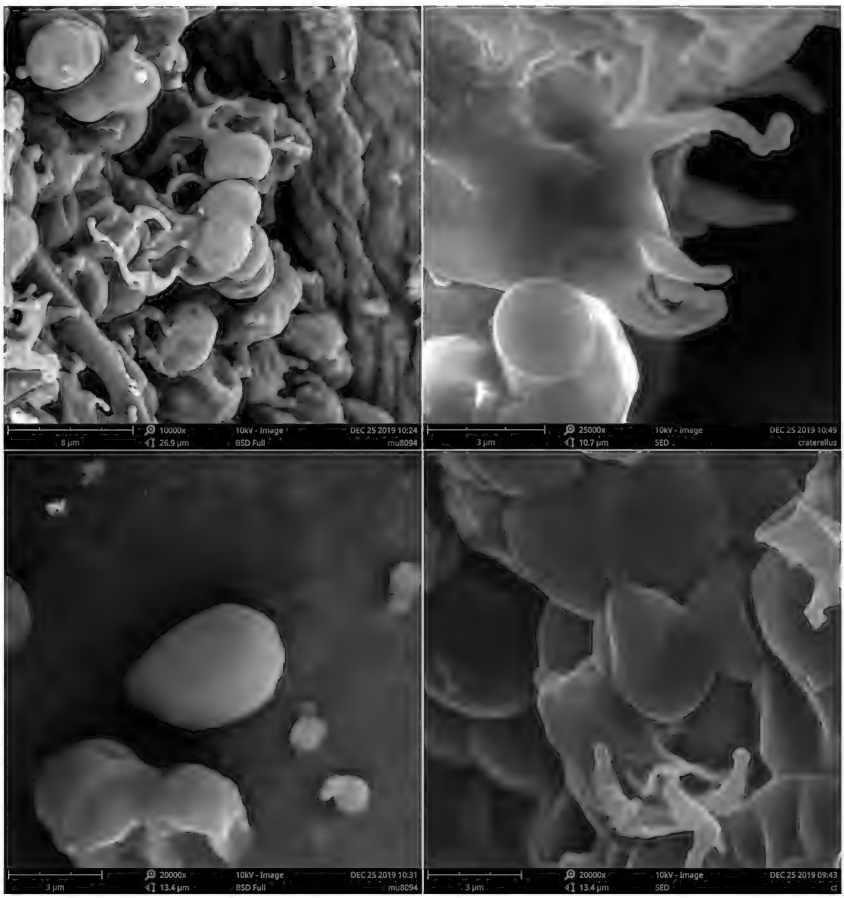
10000x 10kV - Image DEC 25 2019 10:24
8 µm 26.9 µm BSD Full mu8094
25000x 10kV - Image DEC 25 2019 10:45
3 µm 10.7 µm SED craterellus
20000x 10kV - Image DEC 25 2019 10:31
3 µm 13.4 µm BSD Full mu8094
20000x 10kV - Image DEC 25 2019 09:43
3 µm 13.4 µm SED ct

Figure 3. *Craterellus atrobrunneolus* (holotype, IFP 019359). Basidia and basidiospores (SEM).

multiguttulate. Cystidia absent. Hymenium 60–85 µm thick. Hymenophoral trama hyphae 3.5–10 µm diam., thin to slightly thick-walled, more or less interwoven, occasionally branched, often with fine guttules, hyaline to yellowish brown in 5% KOH. Pileal trama hyphae 5.5–10 µm diam., thick-walled, subregular. Pileipellis composed of cylindrical hyphae, 3.5–11 µm diam, thick-walled, frequently branched, somewhat interwoven, with rounded obtuse apex. Stipitipellis composed of interwoven hyphae, 3.5–7.5 µm diam., thick-walled; terminal elements 11.5–29 × 3.5–12 µm. Clamp connections absent in all tissues.

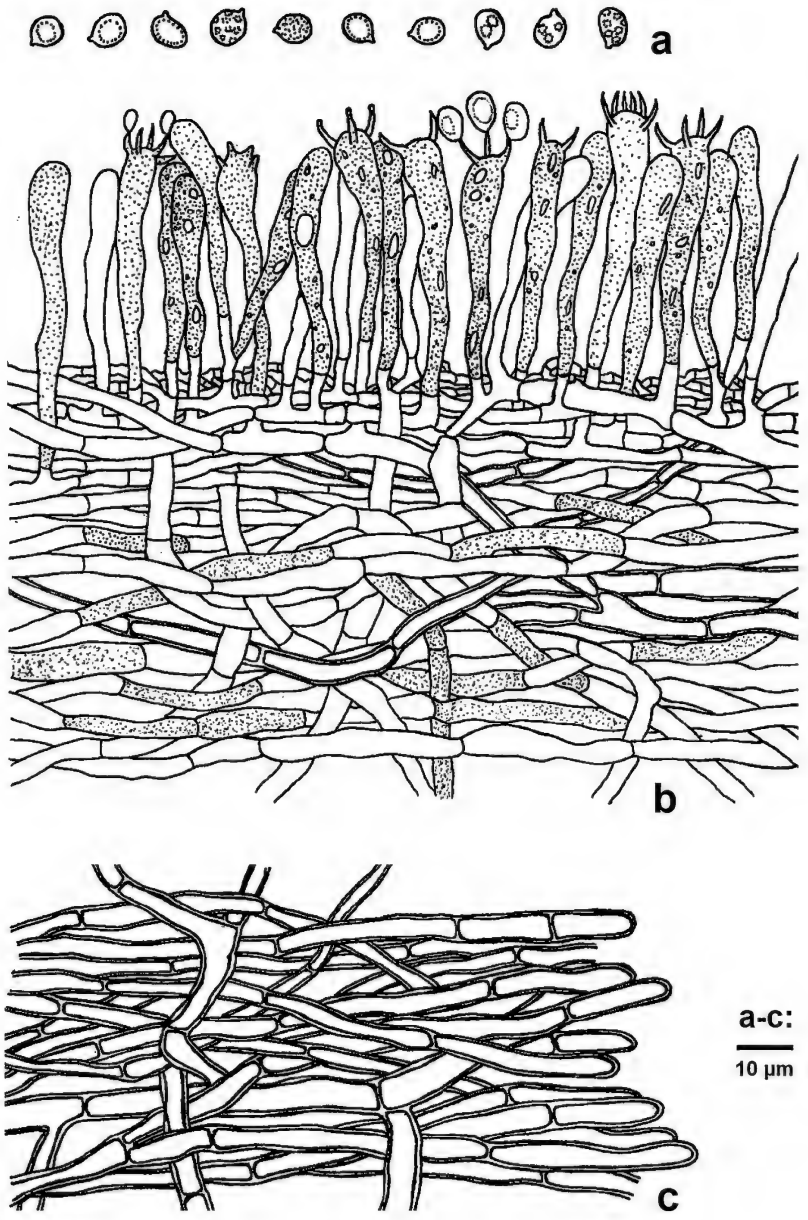

FIGURE 4. *Craterellus atrobrunneolus* (ex holotype, IFP 019359).
a. Basidiospores; b. A section of context and hymenium; c. Pileipellis.

Additional specimen examined— **CHINA. Yunnan Province, Shizong County,** Junzishan Mt., ground in angiosperm forest, 8 Aug 2019, Yuan 13900b (IFP 019360).

Discussion

Craterellus atrobrunneolus is characterized by dark brown to brownish gray basidiocarps, convex to plano-convex pileus with an umbilicate (non-perforated) center, smooth to slightly folded gray to cretaceous hymenophore, narrow basidia with 2–6 sterigmata, and broadly ellipsoid to subglobose basidiospores.

Several *Craterellus* species also have similarly dark colored basidiocarps, such as *C. albostrigosus* C.K. Pradeep & K.B. Vrinda, *C. atratoides* T.W. Henkel & al., *C. atratus* (Corner) Yomyart & al., *C. caeruleofuscus* A.H. Sm., *C. cornucopioides* (L.) Pers., *C. fallax* A.H. Sm., and *C. strigosus* T.W. Henkel & al.

Craterellus albostrigosus, described from India, resembles the new species in its brownish pileus, gray hymenophore, thick-walled pileipellis hyphae, stipitipellis hyphae with short terminal elements, and absence of clamp connections. But *C. albostrigosus* is distinguished by its smaller (3–19 mm diam) pileus with white strigose hairs, a solid stipe with strigose scales, and larger (9–11.5 × 6–8 µm) basidiospores (Bijeesh & al. 2018).

Craterellus atratoides resembles *C. atrobrunneolus* in its grayish brown glabrous pileus and stipe, gray hymenophore, densely guttulate basidioles, and ellipsoid to subglobose basidiospores but is distinguished by its broader (7.1–9 µm diam) basidiospores, larger (79–111 × 7.4–9.9 µm) basidia with 3–5 sterigmata, and abundant clamp connections (Wilson & al. 2012).

Craterellus atratus also shares similarly colored basidiocarps, ellipsoid basidiospores, a smooth to very faintly wrinkled hymenophore, and the absence of cystidia but is separated from *C. atrobrunneolus* by its smaller, campanulate basidiocarps (pileus 8–9 mm, stipe 7–9 × 0.75–1 mm), solid stipe, larger (9 × 6–7 µm) basidiospores, and rare clamp connections (Yomyart & al. 2012).

Craterellus strigosus, described originally from Guyana, resembles *C. atrobrunneolus* in its similarly shaped pileus, gray hymenophore, and multiguttulate basidia but is distinguished by its smaller basidiocarps (4–18 mm broad, 2–9 mm tall), wider (5.9–8 µm diam.) basidiospores, stipe with dense, brown strigose scales, and abundant clamp connections in all tissues (Wilson & al. 2012).

The phylogenetic tree supports *Craterellus atrobrunneolus* as distantly related to *C. odoratus* and *C. luteus*, two species obviously separated from the

new species by their bright orange to greenish yellow pileal surface (Dahlman & al. 2000; Zhong & al. 2018).

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Camposporium chinense sp. nov. from Jiangxi, China

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Abstract—A new species, *Camposporium chinense,* is described and illustrated from a specimen collected on dead branches of an unidentified broadleaf tree in Jiangxi, China. The fungus is characterized by its fusiform, 9–12-septate, versicolored conidia with an unbranched, aseptate apical appendage. A key to *Camposporium* species is provided.

Key words—asexual fungi, hyphomycetes, saprobes, taxonomy

Introduction

Camposporium Harkn. was established by Harkness (1884) for a single species, *C. antennatum* Harkn., and is mainly characterized by solitary acropleurogenous euseptate conidia that secede rhexolytically from polyblastic integrated terminal sympodial extended denticulate conidiogenous cells. The conidia are generally cylindrical or fusiform, smooth, rounded at either or both ends and with one or more unbranched or branched appendages, the base usually bearing a frill (Harkness 1884, Hughes 1951, Ellis 1971, Whitton & al. 2002, Seifert & al. 2011). Of the twenty epithets listed in *Camposporium* by

Index Fungorum (January 2020), sixteen represent accepted *Camposporium* species, distinguished primarily by conidial shape, size, septation, pigmentation, presence or absence of apical appendages, and the characters of apical appendages including branched or unbranched and septate or aseptate. Whitton & al. (2002), who provided a synoptic table of morphological features that distinguish the then-accepted *Camposporium* species, provided a key to 15 species. Adamčík & al. (2015) provided an expanded synoptic table that includes one additional species.

China has an extensive territory with complex ecological environments and abundant plant resources, which provide rich habitats for survival and multiplication of various microbial species. Several mycological investigations dealing with many new genera or species from southern China were published recently (e.g. Xia & al. 2015, 2016, Ma & al. 2016, Ai & al. 2019, Xu & al. 2019). During ongoing mycological surveys in southern China, an interesting hyphomycete with morphological features of *Camposporium* was collected on dead branches. It differs remarkably from previously described taxa, and is proposed here as a new species, *C. chinense*.

Materials & methods

Samples of dead branches were collected from humid environments or waterside in the forests of southern China and taken to the laboratory in Ziploc™ plastic bags, where they were processed and examined as described by Ma & al. (2011). Conidia and conidiophores were measured and photographed using a Nikon Eclipse E200 microscope and a SmartV550Dc digital camera, with a 100× (oil immersion) objective. Adobe Photoshop 7.0 was used for image processing to assemble photographs into a plate, with backgrounds replaced for esthetic reasons. The specimen was deposited in the Herbarium of Jiangxi Agricultural University, Plant Pathology, Nanchang, China (HJAUP).

Taxonomy

Camposporium chinense Z.H. Xu, Jian Ma, X.G. Zhang & R.F. Castañeda, **sp. nov.** FIG. 1

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Differs from *Camposporium fusisporum* by its longer and narrower conidia with a single, aseptate apical appendage; and from *C. laundonii* by its distinctly longer and wider conidiophores and its fusiform conidia with more eusepta and a single, aseptate apical appendage.

TYPE: China, Jiangxi Province, Jinggangshan Mountain, on dead branches of an unidentified broadleaf tree, 6 November 2014, J. Ma (**Holotype**, HJAUP M0298).

ETYMOLOGY: refers to the country in which the fungus was collected.

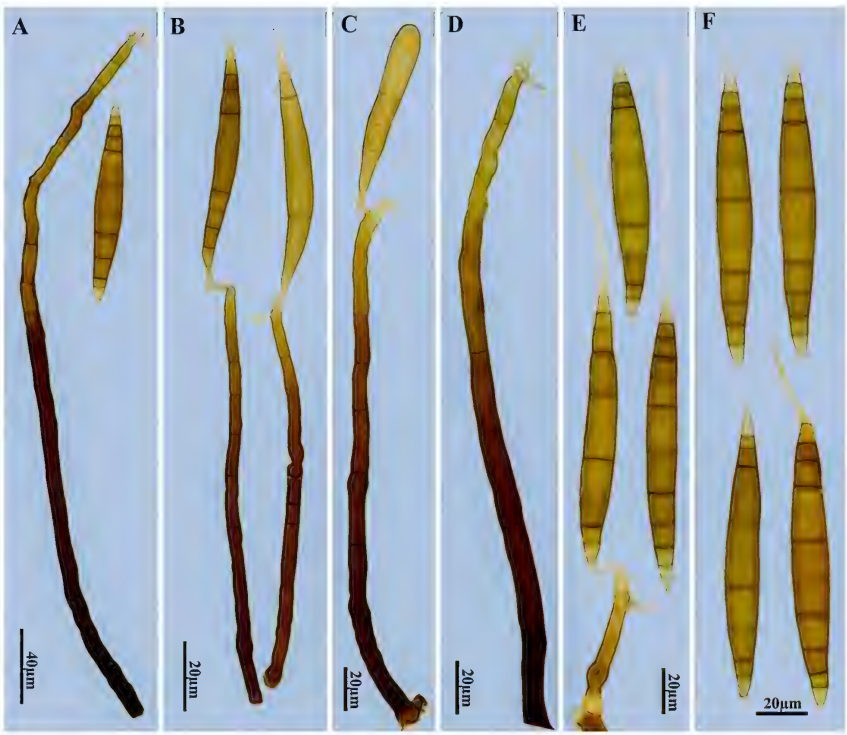

Fig. 1. *Camposporium chinense* (holotype, HJAUP M0298).
A–C. Conidiophores, conidiogenous cells, conidia; D. Conidiophore and conidiogenous cell; E. Conidiogenous cell and conidia; F. Conidia.

Colonies on natural substratum effuse, minute, brown. Mycelium partly superficial, partly immersed, composed of branched, septate, smooth, subhyaline to pale brown hyphae. Conidiophores macronematous, mononematous, unbranched, erect, straight or flexuous, cylindrical, brown to dark brown, paler toward the apex, smooth, 8–16-septate, 220–400 × 7–9.5 μm. Conidiogenous cells polyblastic, terminal, integrated, sympodial extended, denticulate, pale brown to subhyaline, smooth, 18.5–26 × 5–7 μm, with narrowly cylindrical, pale brown, smooth denticles at the conidiogenous loci. Conidial secession rhexolytic. Conidia solitary, acropleurogenous, elongate fusiform, brown or pale brown, the end cells paler than the other 9–12-euseptate, 110–160 × 12.5–16 μm (appendage excluded), truncate at the base, with a distinct basal

frill, 0.5–1.5 µm in length and with an unbranched, continuous, pale brown to subhyaline, smooth apical appendage, ≤100 µm length, 2–3 µm diam.

Comments – Among the known species of *Camposporium*, only *C. fusisporum* Whitton & al. (Whitton & al. 2002) is similar to *C. chinense* in producing typically fusiform conidia, but *C. fusisporum* has shorter and wider conidia (86–115 × 13.5–19 µm) with 2–3 apical appendages (17–40 µm long). Also *C. laundonii* M.B. Ellis (Ellis 1976) bears some resemblance to *C. chinense* in conidial shape, but *C. laundonii* has distinctly shorter and narrower conidiophores (<40 × 5–8 µm), and cylindrical to fusiform, 4–9-euseptate, shorter conidia (50–150 µm long) with 1–2 hyaline, septate apical appendages, ≤60 µm long.

Key to *Camposporium* species

1. Conidia without apical appendages 2
1. Conidia with apical appendages 4
2. Conidia subuliform, hyaline, 48–108 × 3–4 µm, 6–12-euseptate ..... *C. scolecosporium*
2. Conidia cylindrical 3
3. Conidia pale brown, 20–35 × 8–12 µm, (3–)7-euseptate ..... *C. ontariense*
3. Conidia dark brown, paler end cells, 21.6–72 × 3.6–7.2µm, 3–14-euseptate ..... *C. indicum*
4. Conidial appendage branched 5
4. Conidial appendage unbranched 6
5. Conidia pale brown, 40–70 × 6–8 µm, 7–11-euseptate ..... *C. japonicum*
5. Conidia brown, paler end cells, 80–112 × 6.4–9.6 µm, 8–15-euseptate .. *C. ramosum*
6. Conidia concolorous 7
6. Conidia versicolorous 10
7. Conidia with a single, unbranched appendages 8
7. Conidia with 1–2 or 1–4 independent apical appendages 9
8. Conidia cylindrical to fusiform, 20–75 × 3–5 µm, 2–4(–6)-euseptate ..... *C. hyalinum*
8. Conidia cylindrical to cylindric-fusoid, (24.7–)33(–44) × (4.5–)4.7(–6.5) µm, 5–10-euseptate ..... *C. marylandicum*
9. Conidia cylindric-fusoid, 25.8–36 × 7.2–9 µm, 2–6-euseptate, with 1–2 apical appendages ..... *C. microsporum*
9. Conidia cylindrical, 32.4–54 × 3.6–7.2 µm, 5–9-euseptate, with 1–4 apical appendages ..... *C. hyderabadense*
10. Conidia fusiform 11
10. Conidia cylindrical or cylindrical to fusiform 12

11. Conidia 86–115 × 13.5–19 µm, 8–11(mostly 9)-euseptate, with 2–3 apical appendages ..... *C. fusisporum*
11. Conidia 110–160 × 12.5–16 µm, 9–12-euseptate, with a single, continuous apical appendage ..... *C. chinense*
12. Conidia with a single appendage 13
12. Conidia with more than one apical appendage 15
13. Conidia 75.4–85.7 × 7–9µm, 7–10-euseptate, with 0–1 apical, aseptate conidial appendage ..... *C. himalayanum*
13. Conidial appendages septate 14
14. Conidia 62–115 × 8–10 µm, 9–15-euseptate ..... *C. cambrense*
14. Conidia 78–140 × 7.5–12µm, 7–16-euseptate ..... *C. pellucidum*
15. Conidia cylindrical to fusiform, 50–150 × 13–17 µm, 4–9-euseptate ..... *C. laundonii*
15. Conidia cylindrical, not exceeding 78 × 9 µm 16
16. Conidia 42–78 × 7.5–9 µm, 4–14-euseptate ..... *C. antennatum*
16. Conidia 28–45 × 3.5–4.5 µm, 5–9-euseptate ..... *C. quercicola*

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Helicoma barretoi sp. nov. from the Brazilian Atlantic rainforest

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Abstract—A new species, *Helicoma barretoi*, collected on dead twigs in Paraíba State of northeastern Brazil, is described and illustrated. It is distinguished by frequent branched conidiophores, cylindrical conidiogenous cells constricted at basal septa, and broad terminal denticles.

Key words—helicosporic fungi, tropical fungi, *Tubeufiaceae*, *Tubeufiales*

Introduction

During a survey of microfungi on miscellaneous plant debris in the Atlantic rainforest, an interesting specimen related to *Helicoma* Corda (1837) was collected. Based on molecular data, *Helicoma* is phylogenetically placed in the *Tubeufiaceae*, *Tubeufiales* (Barr 1979, Boonmee & al. 2014). Lu & al. (2018) accepted 57 and excluded 12 species, although there are 99 epithets listed in Index Fungorum (2020) and more than a hundred in Mycobank (2020). *Helicoma* is characterized by conidiophores that are macronematous, mononematous, erect, cylindrical, branched or unbranched, and pale brown or dark brown. The conidiogenous cells are mono- or polyblastic, integrated, sympodial, intercalary and/or terminal, cylindrical with tiny or tooth-like denticles, and smooth walled. The conidia are dry, solitary, acropleurogenous or pleurogenous, helicoid, coiled in two or three dimensions (becoming loosely

coiled in water), multiseptate, hyaline to pale brown, and non-hygroscopic (Goos 1986, Seifert 2011, Lu & al. 2018).

Material & methods

Miscellaneous plant debris substrates were collected during expeditions in Fazenda Engenho Mineiro (Areia, Paraíba, Brazil). Samples were placed in separate paper bags, taken to the laboratory, and processed according to Castañeda-Ruiz & al. (2016). The samples were incubated in Petri dish moist chambers at room temperature in polystyrene containers and examined daily. Microfungal reproductive structures placed on microscope slides prepared with PVL (polyvinyl alcohol and lactic acid) were measured and photographed using a microscope equipped with Differential Interference Contrast (DIC). The holotype was deposited in the Herbarium, Universidade Estadual de Feira de Santana, Feira de Santana, Bahia, Brazil (HUEFS).

Taxonomy

Helicoma barretoi G.G. Barreto, L.T. Carmo & Gusmão, **sp. nov.** Plate 1

MB 834819

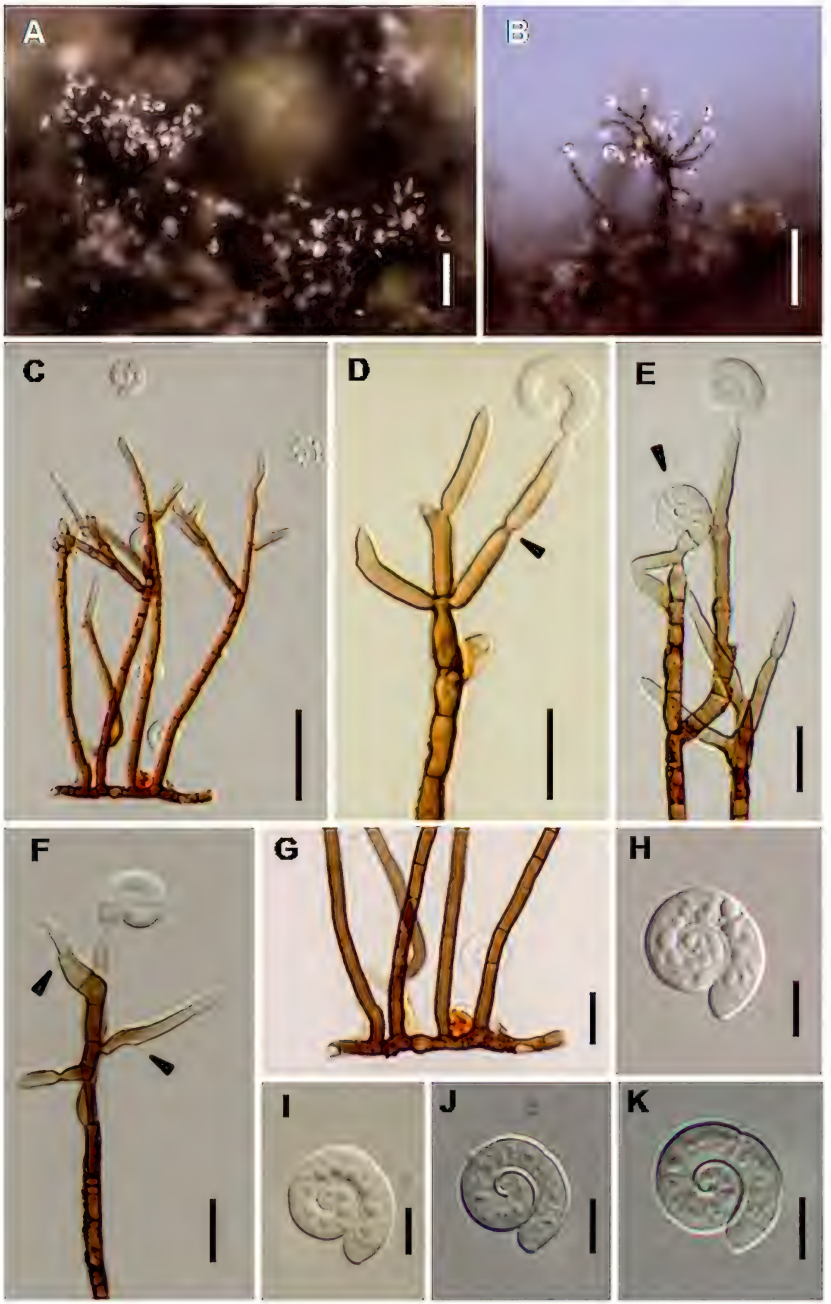
Differs from other *Helicoma* species by its frequently branched conidiophores and cylindrical conidiogenous cells constricted at basal septa and with broad terminal denticles.

Type: Brazil, Paraíba State: Areia, Fazenda Engenho Mineiro, 6°57′48′S 35°41′30′W, on decaying twigs of an unidentified plant, 15.VIII.2019, coll. G.G. Barreto (**Holotype**, HUEFS254151).

Etymology: honoring Francisco Haroldo Barreto, the owner of the farm where the holotype specimen was collected.

Colonies on natural substrate effuse, dark brown. Mycelium immersed and superficial, composed of branched, septate, brown, smooth hyphae, 7–8 µm wide. Conidiophores macronematous, mononematous, cylindrical, erect, slightly flexuous, mostly branched at the apex, sometimes simple, solitary or aggregated in groups, smooth-walled or verrucose at the base, 6–22-septate, sometimes branched, slightly constricted at the septa, dark brown at bases, pale brown toward apex, 90–207.5 × 5–7.5 µm. Conidiogenous cells mono- or polyblastic, integrated, terminal, cylindrical, smooth-walled, with 1–2 percurrent extensions, constricted at the bases, brown to hyaline toward the

Plate 1. *Helicoma barretoi* (holotype, HUEFS 254151): A, B. Colonies on the natural substrate; C. General aspect of conidiophores; D. Conidiogenous cells with constriction (arrow) and young conidia; E. Branched conidiophores with conidia and evident septa (arrow); F. Percurrent extensions (arrows); G. Ornamented basal cells of conidiophores; H–K. Conidia. Scale bars: A, B =100 µm; C = 50 µm; D–G = 20 µm, H–K= 10 µm.


A
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apex, 10–35 × 5–7.5 µm, with terminal and broad denticles, 1.3–1.5 µm diam., pale brown to hyaline toward the denticles. Conidial secession schizolytic. Conidia acrogenous, single, dry, smooth, guttulate, hyaline, tightly coiled 1½ times, 18–23.5 µm diam., conidial filament hyaline, 5–10 µm thick, 9–11 septa (sometimes indistinct), apex rounded, bases truncate, U-shaped, also smooth-walled.

Notes: *Helicoma barretoi* differs from similar species primarily in the (3–4) lateral branching pattern of the conidiophores and the large conidiogenous cell with broad denticles. *Helicoma ambiens* Morgan, which like *H. barretoi* possesses U-shaped basal conidial cells, is distinguished by its rarely branched conidiophores and acropleurogenous conidia (Morgan 1892, Zhao & al. 2007). *Helicoma dennisii* M.B. Ellis produces similarly shaped conidia but is separated from *H. barretoi* by its acropleurogenous and pigmented conidia with V-shaped basal cells and rarely branched conidiophores (Ellis 1963, Zhao & al. 2007). *Helicoma divaricatum* Hol.-Jech. also has similar conidia but can be distinguished by its dichotomously branched conidiophores and acropleurogenous conidia (Holubová-Jechová 1987). *Helicoma vaccinii* Carris, which also produces percurrent proliferations, can be distinguished from *H. barretoi* by its smaller (2–4 µm) conidial filaments, narrower (8–13 µm) conidia, and unbranched conidiophores (Carris 1989, Zhao & al. 2007). *Helicoma guttulatum* Y.Z. Lu & al. and *H. hydei* N.G. Liu & al. have guttulate conidia like *H. barretoi;* however *H. guttulatum* has hyaline to pale brown conidia and unbranched conidiophores (Hyde & al. 2016), and *H. hydei* has unbranched conidiophores and larger conidia (19–39 µm diam; Liu & al. 2019).

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Teratospermopsis gen. nov. for *Chaetendophragmia protuberata*, with a taxonomic review of *Teratosperma*

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Abstract—*Teratospermopsis* is proposed as a new genus for *Chaetendophragmia protuberata* [= *Teratosperma microsporum*]. The genus has acrogenous, solitary, euseptate conidia seceding schizolytically from monoblastic, integrated, terminal, annellidic conidiogenous cells. The conidia are obclavate, smooth, and with an apical cell with a filiform appendage and a basal cell with a lateral appendage. A key and a synoptic table to six accepted *Teratosperma* species accompany comments on four rejected or dubious species, including *T. macrosporum* [= *Endophragmiella macrospora* comb. nov.].

Key words—asexual *Ascomycota*, hyphomycetes, saprobes, taxonomy

Introduction

Teratosperma Syd. & P. Syd. was erected by Sydow & Sydow (1909) with *T. singulare* as the type species, and was mainly characterized by solitary, holoblastic conidia seceding rhexolytically from annellidic conidiogenous cells. The conidia bear lateral appendages which arise from the basal (or occasionally suprabasal) cell (Sydow & Sydow 1909; Ellis 1957, 1971; Wu & Zhuang 2005). Ellis (1957), who examined the type collection of *T. singulare*, monographed

Table 1 Synopsis of accepted species of *Teratosperma*

Species	Conidiophores (µm)	Conidia				Synanamorph
		Size (µm)	Septation	Basal width (µm)	Appendage number/ size (µm)	
T. anacardii [1]	25–100 × 3–5	17–30 × 4.5–7	2–3	1.5–3	1–3/ 2–18 × 2–3	*Selenosporella*-like
T. appendiculatum [1]	20–90 × 3.5–5	17–50 × 7–9	(1–)3(–4)	3.5–4.5	1/ 4–6 × 4.5–5.5	Unknown
T. cornigerum [1]	55–106 × 6–11	70–200 × 14–17	4–12	7–10	1–3/ 10–50 × 2–4	*Selenosporella*-like
T. dicranopteridis [2]	53–230 × 5–13	26–35 × 7.5–9	3–5	4	1–3/ 16–26 × 5–6	Unknown
T. singulare [1]	12–45 × 6–10	60–130 × 17–22	3–10	7–10	1–3/ ≤55 × 5–12	*Selenosporella*-like
T. uniappendiculatum [3]	18–57 × 5.7–7	120–210 × 10–14	6–9	6.2–7.3	1/ 18–40 × 5–7.5	*Verticicladiella*-like

Data from [1] Ellis 1957; [2] Kirschner & al. 2019; [3] Matsushima 1975.

the genus with illustrations and redescriptions of five accepted species: *T. anacardii*, *T. appendiculatum*, *T. cornigerum*, *T. pulchrum*, and *T. singulare*. Hughes (1971) briefly noted the *Endophragmiella*-like proliferations after rhexolytic conidium secession in *T. singulare*, *T. cornigerum*, and *Sporidesmium subulatum*. Later, Hughes (1979) transferred *S. subulatum* and *S. sclerotivorum* (Uecker & al. 1978) to *Teratosperma*, treating *T. pulchrum* as a synonym of *T. cornigerum* and drawing attention to the occurrence of synanamorphs within the genus. Matsushima (1975, 1980) described *T. uniappendiculatum* from Japan and *T. litchii* from Taiwan. Five further species—*T. lichenicola*, *T. oligocladum*, *T. microsporum*, *T. macrosporum*, and *T. dicranopteridis*—were added by Hawksworth (1979), Uecker & al. (1980), Kirk (1985), Wu & Zhuang (2005), and Kirschner & al. (2019). However, *T. litchii,* transferred to *Solicorynespora* R.F. Castañeda & W.B. Kendr. by Castañeda-Ruíz & Kendrick (1990), was later transferred to *Morganjonesia* R.F. Castañeda & al. by Zhang & al. (2019) due to its monotretic conidial ontogeny and conidia with a hyaline, acute or subulate conidial appendage. Subramanian (1992) transferred *T. subulatum* to *Repetophragma* Subram. although its rhexolytic conidial secession differs from that of *Repetophragma* (Hughes 1979). Kirschner & al. (2019) excluded *T. oligocladum* from *Teratosperma* based on the absence of annellidic conidiogenous cells and its conidial appendages arising from suprabasal cells. Thus, eleven species have appeared under the genus *Teratosperma*, most of which are reported to have close associations with lichens, algae, or other fungi (Ellis 1957, Matsushima 1975, Hawksworth 1979, Hughes 1979, Uecker & al. 1980, Kirk 1985, Wu & Zhuang 2005).

It is evident a revision of *Teratosperma* is needed, as the genus has become heterogenous by including species with schizolytic conidial secession (Kirk 1985) as well as species producing conidia without appendages (Hawksworth 1979, Hughes 1979, Wu & Zhuang 2005). Following detailed study of the species and comparison with the type species, *T. singulare*, which has conidia with basal appendages, annellidic conidiogenous cells, and rhexolytic conidial secession, we now accept six species in *Teratosperma* (Table 1). We exclude *T. sclerotivorum* and *T. subulatum,* regard *Teratosperma lichenicola* as synonymous with *Endophragmiella corticola* (Kirk 1982), and transfer *Teratosperma macrosporum* to *Endophragmiella* B. Sutton (Sutton 1973) as a new combination.

Teratosperma microsporum produces conidia with schizolytic conidial secession and a lateral appendage arising from the basal cell, which does not agree with the generic concepts of either *Teratosperma* or *Chaetendophragmia* Matsush. (Matsushima 1971). Therefore we propose a

new genus, *Teratospermopsis*, typified by *Chaetendophragmia protuberata*, with *Teratosperma microsporum* as a heterotypic synonym.

Taxonomy

Teratospermopsis Jian Ma, X.G. Zhang & R.F. Castañeda, **gen. nov.**

IF 557315

Differs from *Teratosperma* by its schizolytic conidial secession; and from *Chaetendophragmia* by its schizolytic conidial secession and its conidial basal cell with a lateral appendage.

Type species: *Chaetendophragmia protuberata* R.F. Castañeda [≡ *Teratospermopsis protuberata* (R.F. Castañeda) Jian Ma & al.]

Etymology: "*Teratosperm-*" from the Latin *Teratosperma*, "*opsis*" = similar, referring to the similarity of the genus to *Teratosperma*.

Conidiophores macronematous, mononematous, single or in groups, simple, cylindrical, erect, straight or flexuous, smooth, septate, pale brown to dark brown, determinate or with percurrent proliferations. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, pale brown to brown. Conidial secession schizolytic. Conidia acrogenous, solitary, appendiculate, obclavate or fusiform, sometimes rostrate, brown to dark brown, euseptate, with one or more lateral appendages arising from the basal cell.

Teratospermopsis protuberata (R.F. Castañeda) Jian Ma, X.G. Zhang & R.F. Castañeda, **comb. nov.** Fig. 1

IF 557316

≡ *Chaetendophragmia protuberata* R.F. Castañeda, Deuteromyc. Cuba, Hyphomycetes 3: 7 (23 May 1985).

= *Teratosperma microsporum* P.M. Kirk, Mycotaxon 23: 345 (19 July 1985), [as '*microspora*'].

Comments—*Chaetendophragmia protuberata* and *Teratosperma microsporum* are proposed as synonyms, based on close examination of their descriptions and illustrations. Both names were proposed in 1985, but *C. protuberata* [accepted 30 April (Castañeda-Ruíz 1985: 1); published 23 May (Castañeda-Ruíz pers. comm.)] has priority over *T. microsporum* [published 19 July (Mycotaxon 24: inside front cover)].

Teratospermopsis protuberata is quite different from *Chaetendophragmia* and *Teratosperma* by its schizolytic conidial secession, and further from *Chaetendophragmia* which produces conidia with lateral appendages arising from the middle cells. The species shares a similar conidial ontogeny with *Repetophragma* (Subramanian 1992) but differs by producing conidia with a

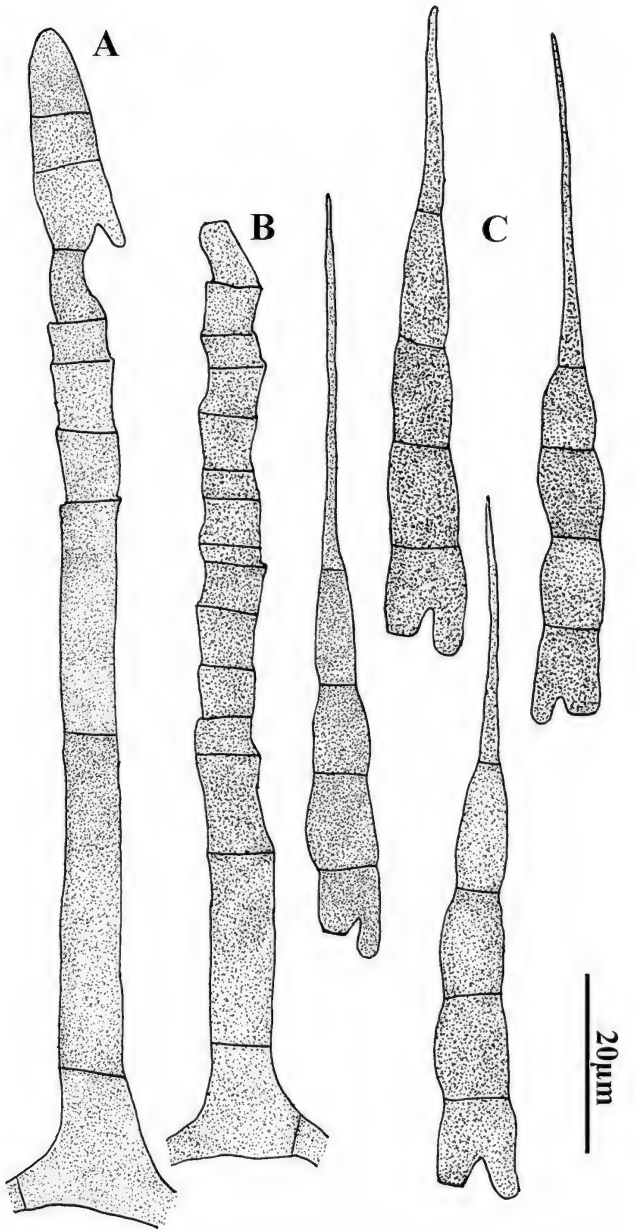

Fig. 1. *Teratospermopsis protuberata* (holotype, INIFAT C85/77-3).
A. Conidiophore, conidiogenous cell, and conidium;
B. Conidiophore, and conidiogenous cell; C. Conidia.

lateral appendage arising from the basal cell. As its morphology prohibits this fungus from inclusion in any previously described hyphomycete genus, we erect a new genus, *Teratospermopsis*, to accommodate it.

Currently accepted *Teratosperma* species

Teratosperma anacardii Hansf., Proc. Linn. Soc. London 155: 54 (1943).
≡ *Podoconis anacardii* (Hansf.) S. Hughes, Mycol. Pap. 48: 65 (1952).

Comments—Hansford (1943) assigned this fungus to *Teratosperma*, but Hughes (1952) transferred it to *Podoconis* Boedijn due to conidial development and morphological characters. Hughes (1952) pointed out that a *Selenosporella*-like synanamorph occurs on conidia of this species, or on independent conidiophores. Ellis (1957) examined the type and other specimens of this species and still accepted it in *Teratosperma* by virtue of annellidic conidiogenous cells that produce phragmoconidia with 1–3 lateral appendages from the basal cell. Ellis (1958) synonymised *Podoconis* under *Sporidesmium* Link, but *P. anacardii* differs from *Sporidesmium* by its annellidic conidiogenous cells that produce conidia with basal appendages, and rhizolytic conidial secession. Following Ellis (1957), the basionym *Teratosperma anacardii* has been accepted by Hawksworth (1979) and Kirschner & al. (2019) and is considered the appropriate name. This species has been reported from Ghana, New Guinea, Nigeria, Sierra Leone, Uganda, and Tanzania (Ellis 1957, Hawksworth 1979).

Teratosperma appendiculatum (S. Hughes) M.B. Ellis, Mycol. Pap. 69: 6 (1957).
≡ *Annellophora appendiculata* S. Hughes, Trans. Br. Mycol. Soc. 34(4): 548 (1952 ["1951"]).

Comments—This species was originally assigned to *Annellophora* S. Hughes, and subsequently transferred to *Teratosperma* by Ellis (1957) based on its phragmoconidia with a single lateral appendage arising from the basal cell. A *Selenosporella*-like synanamorph has not been recorded for this species. *Teratosperma appendiculatum* is morphologically most similar to *T. anacardii*, but differs mainly in conidial size, basal scar width, and size and number of appendages. This species has been recorded from Brazil, Ghana, and USA (Ellis 1957, Sutton & Hodges 1977).

Teratosperma cornigerum (Ellis & Everh.) M.B. Ellis, Mycol. Pap. 69: 5 (1957).
≡ *Clasterosporium cornigerum* Ellis & Everh., Proc. Acad. Nat. Sci. Philad. 43: 91 (1891).
= *Clasterosporium pulchrum* Ellis & Everh., Proc. Acad. Nat. Sci. Philad. 45: 169 (1893).
≡ *Teratosperma pulchrum* (Ellis & Everh.) M.B. Ellis, Mycol. Pap. 69: 4 (1957).

Comments—Ellis (1957) examined the type specimens of *Clasterosporium cornigerum* and *C. pulchrum*, and transferred them both into *Teratosperma* based on their annellidic conidiogenous cells producing phragmoconidia with 1–3 lateral appendages from the basal cell. Ellis (1971) pointed out that *T. cornigerum* and *T. pulchrum* were possibly conspecific, although their type specimens looked different. Hughes (1979), who examined the type and five other specimens, treated *T. pulchrum* as a synonym of *T. cornigerum* but did not explain or justify his decision. *Teratosperma cornigerum* has been recorded from Canada, China, USA, and UK (Ellis 1957, Hughes 1979, Wu & Zhuang 2005, Xia & al. 2016).

Teratosperma dicranopteridis R. Kirschner, Taiwania 64(2): 172 (2019).

Comments—*Teratosperma dicranopteridis* was described on discolored living and dead leaves of *Dicranopteris linearis* in Taiwan and is characterized by annellidic conidiogenous cells that produce obclavate, 3–5-septate conidia with the basal cell bearing 1–3 lateral, 2–4-septate appendages. Secondary conidium production was not found on this species. Kirschner & al. (2019) compared this species with closely related species, *T. anacardii* and *T. singulare* based on conidial size and appendages.

Teratosperma singulare Syd. & P. Syd., Ann. Mycol. 2: 172 (1909).

Comments—*Teratosperma singulare* is the type species of *Teratosperma* and is known on woody plants including *Fagus crenata, Liquidambar macrophylla, Quercus germana, Ulmus parvifolia,* and *U. macrocarpa,* usually in association with other fungi. This species has been reported from China, Japan, and Mexico (Ellis 1957, 1971, Matsushima 1975, Guo 1989, Heredia & al. 1995, Wu & Zhuang 2005, Kobayashi 2007).

Teratosperma uniappendiculatum Matsush.,
Icon. Microfung. Matsush. Lect.: 152 (1975).

Comments—Matsushima (1975) described this species on dead leaves of *Osmanthus ilicifolius* and discovered the "*Verticicladiella*-like" anamorph in culture. *Teratosperma uniappendiculatum* bears some resemblance to *T. cornigerum* in conidial shape but is distinguished by its narrower conidia with fewer basal appendages. Sutton & Hodges (1977) redescribed it from bark of *Eucalyptus saligna* in Brazil. This species has been reported from Brazil, China, Japan, and USA (Matsushima 1975, Sutton & Hodges 1977, Wu & Zhuang 2005).

Rejected or dubious *Teratosperma* species

Endophragmiella macrospora (W.P. Wu) Jian Ma, X.G. Zhang & R.F. Castañeda, **comb. nov.**

IF 557317

≡ *Teratosperma macrosporum* W.P. Wu, Fungal Divers. Res. Ser. 15: 326 (2005).

Comments—To our knowledge, this species is known only from its type collection. Its conidial appendages arise from apical and subapical cells, not from the basal cell, rendering it nontypical in *Teratosperma;* however a similar characteristic was also found in *Endophragmiella gardeniae* Jian Ma & X.G. Zhang and *E. machili* Jian Ma & X.G. Zhang (Ma & al. 2012). In addition, the species exhibits percurrently extending conidiogenous cells and rhexolytic conidial secession. Thus, we transfer *T. macrosporum* to *Endophragmiella,* where it is easily distinguished from *E. gardeniae* and *E. machili* by its conidial size and septation.

Endophragmiella corticola P.M. Kirk, Trans. Br. Mycol. Soc. 78(1): 60 (1982).

= *Teratosperma lichenicola* D. Hawksw., Bull. Brit. Mus. (Nat. Hist.), Bot. 6(3): 262 (1979).

Comments—After examining a single collection, Hughes (1952) determined this fungus as *Podoconis* sp. based on the conidial shape Hawksworth (1979), who discovered additional material, described it as a new *Teratosperma* species with close affinity to *T. anacardii.* Our examination of the description and illustration of *T. lichenicola* revealed that this fungus differed from the generic concept of *Teratosperma* in lacking conidial appendages on the basal cell. Instead, it exhibits the key characters of *Endophragmiella:* percurrently proliferating conidiogenous cells, rhexolytic conidial secession, and solitary conidia without lateral appendages. This fungus has obclavate, brown to dark brown, 2–3-septate conidia with a subhyaline or pale brown apical cell occasionally bearing a *Selenosporella*-like synanamorph, all characters found in *E. corticola*, except for the synanamorph. We consider *T. lichenicola* and *E. corticola* to be conspecific.

Teratosperma sclerotivorum (Uecker, W.A. Ayers & P.B. Adams) S. Hughes, New Zealand J. Bot. 17: 178 (1979), [as '*sclerotivora*'].

≡ *Sporidesmium sclerotivorum* Uecker, W.A. Ayers & P.B. Adams, Mycotaxon 7: 276 (1978).

Comments—Uecker & al. (1978) tentatively placed this fungus in *Sporidesmium*. It is characterized by the formation of solitary, holoblastic conidia on simple or branched conidiophores, which sometimes undergo percurrent proliferation,

and by the production of a *Selenosporella*-like synanamorph. The gently tapered, phragmoseptate conidia secede rhexolytically from conidiogenous cells. Based on these features, Hughes (1979) transferred it to *Teratosperma*. However, the species lacks the distinctive conidial basal appendages and does not fully conform to what can be considered the central, hallmark characteristics by which *Teratosperma* is conceptualized, and its presence in *Teratosperma* has not been generally accepted (Bullock & al. 1989, Litkei 1989, Mischke & Adams 1996, Mischke 1998). Moreover, the rhexolytic conidial secession of this species does not conform to that of *Sporidesmium*. Wu & Zhuang (2005) redescribed *T. sclerotivorum* from fungal sclerotia and decaying leaves of unidentified plants in China, but their description does not mention a conidial appendage arising from the basal cell and differs from the description by Uecker & al. (1978) in citing longer and narrower [55–130 × 5–6.5 µm vs 60–92 × 6–8 µm] conidia with more [8–19 vs (5–)6(–7)] septa, and the production of a *Selenosporella*-like synanamorph on conidial apex, not on the hyphae as described by Uecker & al. (1978). Based on the difference, we believe these specimens are not conspecific and exclude the species from *Teratosperma*.

Teratosperma subulatum (Cooke & Ellis) S. Hughes,
New Zealand J. Bot. 17: 178 (1979).
≡ *Ceratophorum subulatum* Cooke & Ellis, Grevillea 17(83): 67 (1889).
≡ *Sporidesmium subulatum* (Cooke & Ellis) S. Hughes, Mycol. Pap. 36: 31 (1951).
≡ *Repetophragma subulatum* (Cooke & Ellis) Subram., Proc. Indian Natn. Sci. Acad. B 58(4): 185 (1992), [as '*subulata*'].

Comments—This species was originally described in *Ceratophorum* Sacc., and subsequently transferred to *Sporidesmium* by Hughes (1951) based on the absence of a superficial 'hyphopodiate' foliicolous mycelium (Cooke 1889, Hughes 1951). After examining a second collection, Hughes (1979) recombined the species in *Teratosperma* based on the rhexolytic conidial secession, annellidic conidiogenous cells, conidial morphology, and production of a *Selenosporella*-like synanamorph. However, the absence of the distinctive lateral appendages in conidia basal cell renders this species atypical in *Teratosperma*. In addition, its sequence of septum formation in conidia differs from that found in *Endophragmiella socia* and *E. valdiviana* (Hughes 1979). Subramanian (1992), who transferred this species into *Repetophragma* based on its distinctive conidiophore proliferation and euseptate conidial septation, ignored the conidial secession, which was quite different from *Repetophragma* species. Therefore, the placement of this fungus in a suitable genus is problematic.

Key to accepted species of *Teratosperma*

1. Conidia with a single lateral appendage arising from the basal cell 2
1. Conidia with more than one lateral appendage arising from the basal cell 3
2. Conidia 17–50 × 7–9 µm, (1–)3(–4)-septate ..... *T. appendiculatum*
2. Conidia 120–210 × 10–14 µm, 6–9-septate ..... *T. uniappendiculatum*
3. Conidia ≤40 × 10 µm 4
3. Conidia ≥60 × 14 µm 5
4. Conidia 17–30 × 4.5–7 µm, 2–3-septate ..... *T. anacardii*
4. Conidia 26–35 × 7.5–9 µm, 3–5-septate ..... *T. dicranopteridis*
5. Conidia 70–200 × 14–17 µm, 4–12-septate ..... *T. cornigerum*
5. Conidia 60–130 × 17–22 µm, 3–10-septate ..... *T. singulare*

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Smardaea isoldae sp. nov. from a tropical cloud forest in Mexico

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Abstract—*Smardaea isoldae* is described from Sierra Madre Oriental, Hidalgo State, Mexico. The new species is distinguished by its olivaceous coloration, habit on dead wood, and tropical cloud forest habitat. The holotype is deposited in ENCB Herbarium. A key to *Smardaea* species is presented.

Key words— *Pyronemataceae*, *Pezizales*, *Pezizomycetes*, taxonomy

Introduction

Smardaea was described by Svrček (1969) based on the type species *Ascobolus amethystinus* W. Phillips. The genus is characterized by its discoid to cupuliform apothecia and purple, blue purple, violet, dark violet, black purple to black colors. The ectal excipulum comprises globose or angular cells and the medullary excipulum is composed of interwoven septate hyphae. The operculate asci are cylindrical with inamyloid apices and the ascospores are globose, ellipsoid or fusoid with smooth, verrucose, or tuberculate walls. The apothecia are found on sandy soil, leaf litter, mosses, and decayed wood. The genus at present includes 10 species, described from Europe, Australia, and Asia: *Smardaea amethystina* (W. Phillips) Svrček, *S. australis* P.S. Catches. & D.E.A. Catches., *S. marchica* (Benkert & J. Moravec) Benkert, *S. microspora* J.Z. Cao & al, *S. ovalispora* (Grelet) Van Vooren, *S. planchonis* (Dunal ex Boud.) Korf & W.Y. Zhuang, *S. protea* W.Y. Zhuang & Korf, *S. purpurea* Dissing, *S. reticulosperma* (Donadini & al) Benkert, and *S. verrucispora* (Donadini &

Monier) Benkert (Svrček 1969, Brummelen 1969, Dissing 1985, Zhuang & Korf 1986, Cao & al. 1990, Korf & Zhuang 1991, Benkert 2005, Van Vooren 2009, Moyne & al. 2010, Catcheside & al. 2017). Only *S. planchonis* has been reported from the western hemisphere (Seaver 1942: Bermuda; Gamundí 1960: Argentina; Hanlin 1965 and Pfister 1985: USA). During taxonomic work in the Sierra Madre Oriental of Hidalgo state, Mexico, several specimens of a *Smardaea* growing on dead wood in tropical cloud forest could not be placed in any previously described species. Here we describe and illustrate those specimens as *Smardaea isoldae*.

Materials & methods

The specimens were collected during 2012–2018 from two localities in a tropical cloud forest of Tlanchinol municipality, State of Hidalgo, Sierra Madre Oriental, Mexico. They are deposited in the "Dr. Gastón Guzmán Huerta" fungal collection of the Herbarium of the Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, Mexico City, Mexico (ENCB). Georeferences were obtained with Garmin eTrex® GPS. Color codes follow Kornerup & Wanscher (1978). Microscopic observations were taken from tissues rehydrated in 5% aqueous KOH and Melzer's reagent; ascospore dimensions include the ornamentation. Macroscopic features were photographed with a Nikon D7000 camera and the micrographs with a Sony DSC-WX350. For the SEM studies, the sample was prepared according to the critical-point-drying method outlined in Moreno & al. (1995) and examined with a JSM-5800LV scanning electron microscope. Most terminology follows Ulloa & Hanlin (2012), with Ekanayaka & al. (2017) for the types of ectal and medullary excipulum.

Taxonomy

Smardaea isoldae Raymundo & R. Valenz., **sp. nov.** PLATES 1–3

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Differs from *Smardaea amethystina* by its olive green, greyish green, dark green to olive brown hymenium; its larger ascospores; and its habitat on dead wood in a tropical cloud forest.

TYPE: Mexico, Sierra Madre Oriental, Hidalgo State, Tlanchinol municipality, El Temazate, 21°01′40″N 98°38′33″W, alt. 1500 m, 31 May 2018, R. Valenzuela 18324 (**Holotype**, ENCB).

ETYMOLOGY: In honor of Dr. Isolda Luna Vega, pioneer in the study of fungal biogeography in Mexico.

APOTHECIA 2–4 mm diam., sessile on a broad base, pulvinate, cup shaped when young, then flattened to discoid, flesh soft to gelatinous, dark olive (3F3) to black, yielding yellow (3A8) KOH-extractable pigments. HYMENIUM 300–320 µm thick, smooth, olive green (3D7) or olive (3F7) when young, then

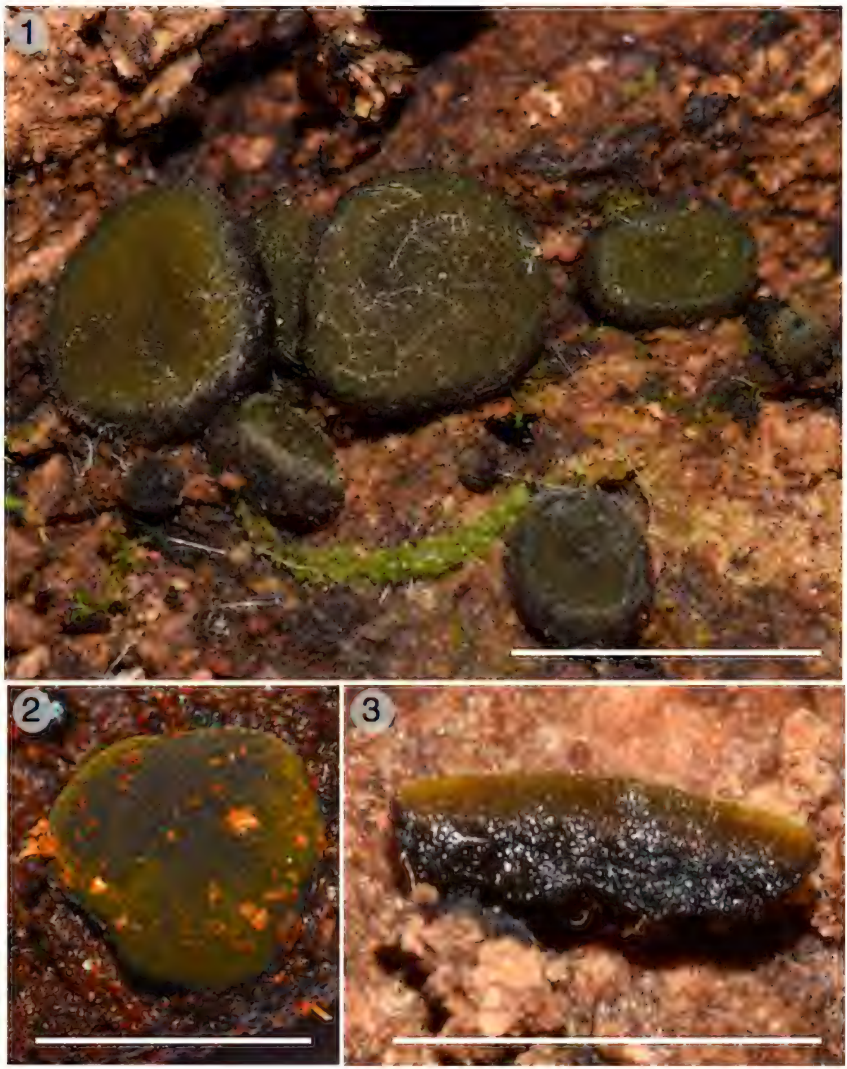

Plate 1. *Smardaea isoldae* (holotype, ENCB Valenzuela 18324). 1. Gregarious young and mature apothecia on dead wood; 2. Mature discoid apothecium; 3. Apothecium, transverse section. Scale bars = 5 mm.

olive gray (3E2), olive brown (4E5, 4F6), dull green (30E3), or greyish green (30E7), black in dry specimens. External surface olive grey (3F2), dark olive (3F3), brownish grey (4F2), dark olive brown (4F3) to black, slightly rugose.

Ectal excipulum 90–120 µm thick at the margin and ≤200 µm thick in the base, textura globulosa to angularis from base to margin, globose cells 15–28 µm diam., subglobose to elongated cells 16.5–42.5(–60) × 10–20(–25) µm; walls ≤3 µm thick, amber (6D6), wine red (11D8) to deep magenta (13-14D8). Medullary excipulum 260–300 µm thick, textura intricata intermixed with globose to subglobose cells, hyphae 2.5–7.5 µm diam., pale yellow to light purplish in KOH, septate, branched, thin-walled, globose to subglobose cells 8–15(–25) µm broad, walls ≤2 µm thick, pale yellow to light purplish in KOH. Subhymenium 15–25 µm thick, textura globulosa mixed with few short, branching, septate, thin-walled hyphae, 2–4 µm diam, globose to subglobose cells, 3–7 µm diam., thin-walled, hyaline to pale yellow in KOH. Paraphyses 300–340 µm long, filiform, ≤25 µm beyond the asci, 2–4 µm diam., unbranched, septate, hyaline, pale yellow to light purple in KOH, with swollen apex, clavate to capitate, 6–12 µm diam. at the top. Asci operculate, inamyloid, 8-spored, 270–300 × 16–18(–20) µm, cylindrical, hyaline. Ascospores 22–28 × 10–14 (–15) µm, oblong to fusiform, hyaline in KOH, inamyloid, surface covered by coarse, hyaline, rounded warts or tubercles, 1.5–3 µm high, and semiglobular apiculi at the ends, 2–4 µm high and 3.5–5.5 µm wide.

Ecology and distribution—gregarious on decayed angiosperm wood in a tropical cloud forest.

Additional specimens examined—**MEXICO. Hidalgo, Tlanchinol municipality**, El Temazate, 21°01′40″N 98°38′33″W, alt. 1500 m, 17 May 2014, R. Valenzuela 15477, T. Raymundo 5070, 5083, 5090, 5091 (all in ENCB); Parador la Montaña, 21°01′40″N 98°38′34″W, alt. 1500 m, 27 May 2012, T. Raymundo 4188, R. Valenzuela 14695, S. Bautista-Hernández 17; C. Santamaria 19 (all in ENCB).

Comments—*Smardaea* has been described with purple pigments in the apothecia and with differently shaped and ornamented ascospores. The olive green to dull green hymenium and dark olive to black external surface colors of our Mexican specimens are unusual in *Smardaea*, but the textura of ectal and medullary excipulum corresponds to the structure described for the genus, and the spore ornamentation for *S. isoldae* is similar to that of the type species (*Smardaea amethystina*). *Aleurina* also exhibits an olivaceous, olivaceous brown, brown, or purplish brown hymenium when fresh, and some *Aleurina* species have ascospores ornamented with rounded warts similar to *Smardaea amethystina* and *S. isoldae* (Zhuang & Korf 1986). However, these *Smardaea* species have semiglobular apiculi at the ends, which are not present in *Aleurina* species (Zhuang & Korf 1986), supporting the Mexican material in *Smardaea*. Perry & al. (2007) supported *Aleurina* and *Smardaea* as independent genera because they are in different clades.

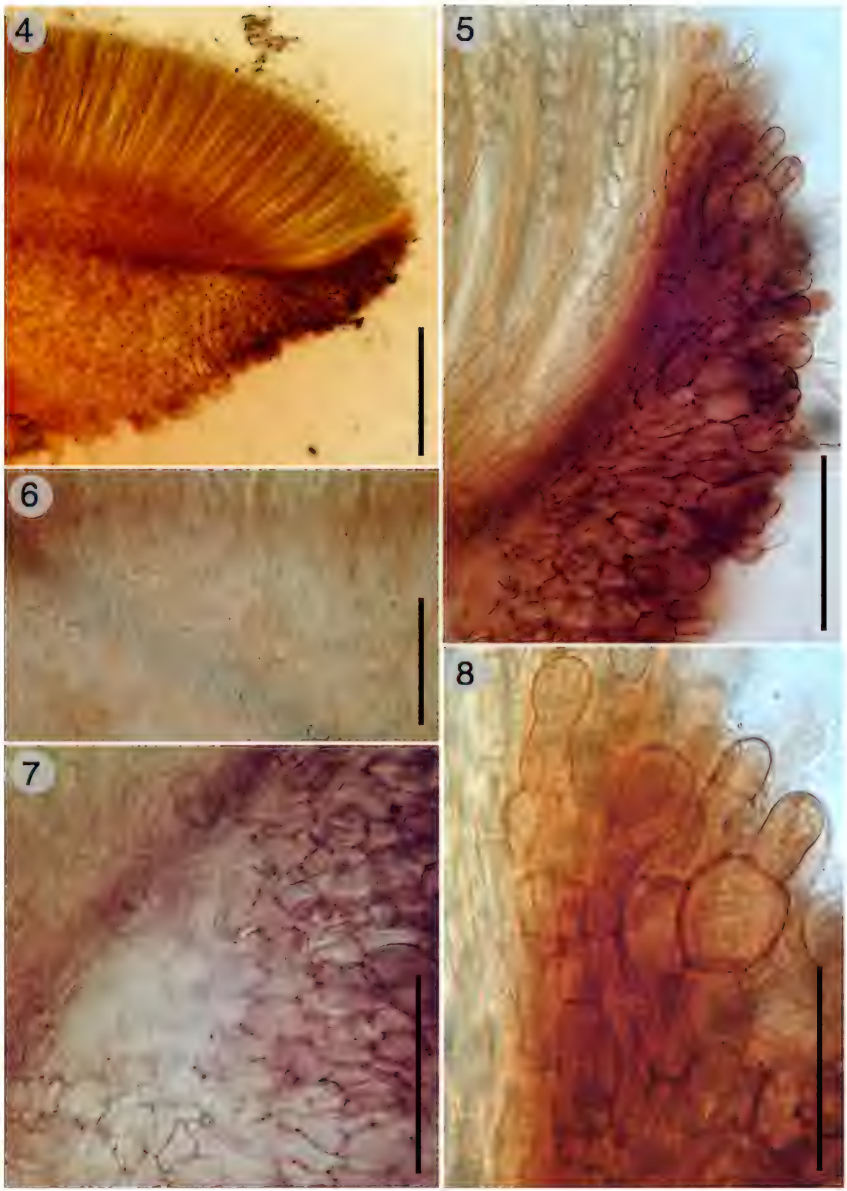

Plate 2. *Smardaea isoldae* (holotype, ENCB Valenzuela 18324). 4. Apothecium, transverse section; 5. Ectal excipulum in margin; 6. Medullar excipulum; 7. Basal ectal excipulum with textura globulosa to prismatica and medullar excipulum with textura intricata; 8. Marginal ectal excipulum (textura globulosa to prismatica). Scale bars = 4 = 300 µm; 5–8 = 100 µm.

Smardaea isoldae is characterized by the green to olivaceous hymenium and external surface, shape, size, and ornamentation of the ascospores and its growth on dead wood in a tropical cloud forest. Our new species resembles *Smardaea amethystina* in spore ornamentation and the semiglobular apiculi, but *S. amethystina* differs in its purple apothecial color, smaller (19.5–22 × 11–12.5 µm) ascospores, and sandy substrate (Brummelen 1969, as *Jafnadelphus amethystinus*). The other *Smardaea* species (i.e., *S. australis*, *S. marchica*, *S. planchonis*, *S. reticulosperma*, *S. verrucispora*) differ in their globose to subglobose ascospores. Ascospores of several other species share the ellipsoid to oblong or fusoid shape found in *S. isoldae* but are characterized by a finely rugose, subreticulate to reticulate ornamentation; *S. ovalispora*, *S. microspora*, *S. protea*, *S. purpurea*. *S. australis*, and *S. planchonis* have smooth to very finely ornamented spores (Donadini 1976, 1984, Torre & al.1988, Benkert 2005, Seaver 1942, Hanlin 1965).

Key to species of *Smardaea*

1. Ascospores globose to subglobose 2
1. Ascospores ellipsoid to fusiform 6
2. Ascospores finely verrucose to reticulate 3
2. Ascospores smooth, 8–10.5(–11.5) µm diam. ..... ***S. australis***

   Apothecia (3–)5–15 mm diam., cupulate, hymenium fuscous-black, violaceous black to blackish-purple; paraphyses filiform, straight or slightly curved, sparsely septate, tips slightly swollen, 2–7 µm diam.; known only from Australia, associated with moss: *Leucopogon parviflorus*, *Melaleuca* sp., and *Acacia longifolia* subsp. *sophorae*, on low sand dune (Catcheside & al. 2017: 19)

3. Ascospores globose, 9–12 µm diam., smooth, warted or reticulate 4
3. Ascospores subglobose, 13–15 × 12–14 µm, coarsely warted ..... ***S. marchica***

   Apothecia 4–5 mm diam., discoid, dark violaceous brownish to almost black; paraphyses filiform, septate, unbranched, apex swollen, 4–7(–11) µm diam.; known only from Germany growing on sandy soil under *Pinus sylvestris* (Benkert & Moravec 1986: 89, Benkert 2005: 144, 151)

4. Ascospores coarsely verrucose or reticulate 5
4. Ascospores smooth to minutely verrucose ..... ***S. planchonis***

   Apothecia 10–20 mm diam., discoid to cupulate, hymenium violaceus purple to black purple; paraphyses filiform, simple to branched, septate, apex slightly swollen 4.5–8 µm diam.; known from Europe, Bermuda, USA, and Argentina growing in sandy soil or leaf litter under *Cupressaceae* in Europe, *Yucca* in USA (Seaver 1942: 74, Hanlin 1965: 135, Donadini 1976: 256)

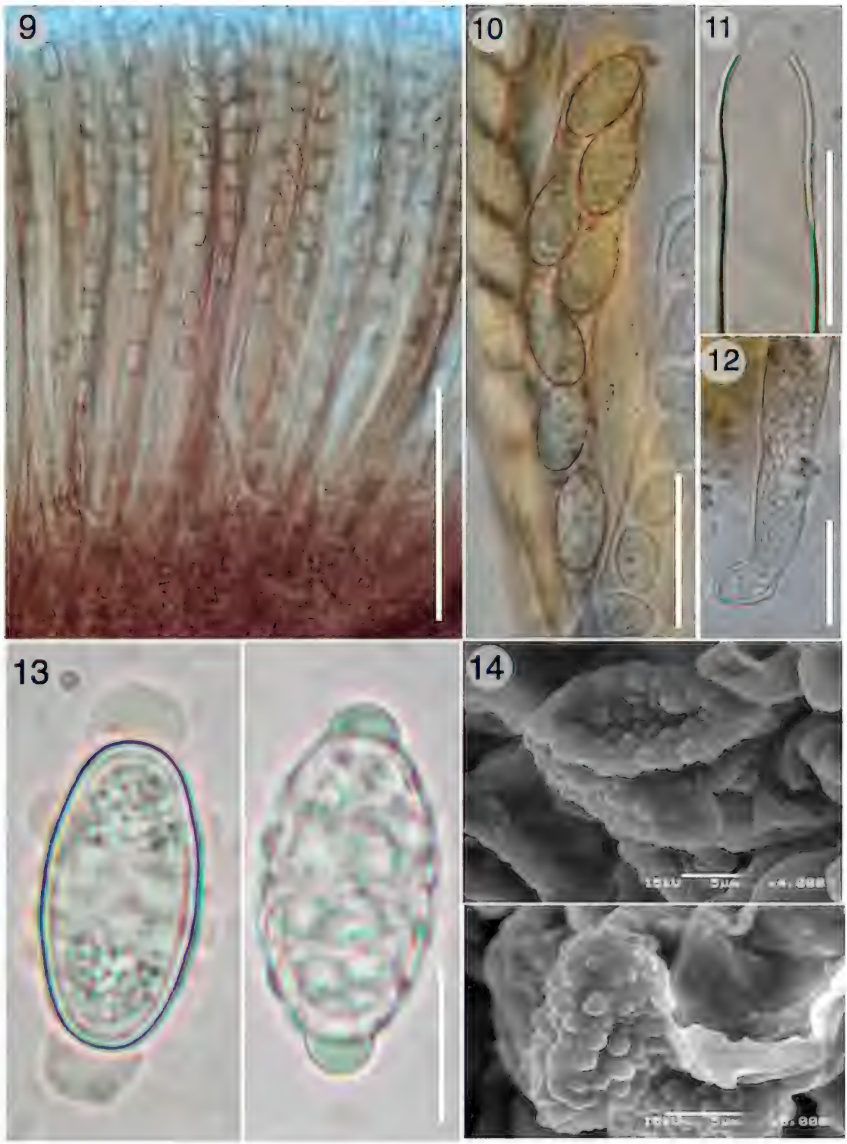

Plate 3. *Smardaea isoldae* (holotype, ENCB Valenzuela 18324). 9. Hymenium with asci, ascospores, and paraphyses; 10. Asci and ascospores; 11. Operculate ascus; 12. Base of ascus; 13. Ascospores in 5% KOH; 14. Ascospores in scanning electronic microscope (SEM). Scale bars: 9 = 100 µm; 10–12 = 20 µm; 13 = 10 µm.

5. Ascospores verrucose (warts ≤1 µm high), 9–12 µm diam. ..... ***S. verrucispora***
Apothecia 5-15 mm diam., cupulate, hymenium violet to purple; paraphyses filiform, straight or slightly curved, branched at base or simple, septate, tips slightly swollen 3.5–5 µm diam.; known only from France on humus under cedars (Donadini 1976: 259)

5. Ascospores reticulate, 10–11 µm diam. ..... ***S. reticulosperma***
Apothecia 10–40 mm diam., cupulate, hymenium violet to purple; paraphyses filiform, slightly curved, branched, septate, tips slightly swollen 3–5 µm diam.; known only from France on humus under *Cedrus atlanticus* (Donadini 1986: 54, 58)

6. Ascospores oblong to fusiform, more than 15 µm long 7

6. Ascospores ellipsoid, smooth, 12–14 × 8–9(–10) µm ..... ***S. ovalispora***
Apothecia 8–15 mm diam., cupulate, hymenium violet; paraphyses filiform, curved at apex, branched at base, septate, tips slightly swollen 2.5(–4) µm diam.; known from France and Spain on humus under *Pinus halepensis*, *Pinus sylvestris,* and *Cedrus atlanticus* (Donadini 1976: 258, Van Vooren 2009: 23, 24)

7. Ascospores with irregular lower ridges to reticulate 8

7. Ascospores finely verrucose to tuberculate 9

8. Ascospores finely reticulate when mature, ornamentation ≤0.5 µm high ..... ***S. microspora***
Apothecia 3–6 mm diam., discoid, hymenium purple to black purple; paraphyses filiform, unbranched, septate, tips swollen 4–7.5 µm diam.; known only from China on sandy soil (Cao & al.1990: 283)

8. Ascospores coarsely warted to reticulate when mature, ornamentation 1–3 µm high ..... ***S. purpurea***
Apothecia 2.5–7 mm diam., discoid, hymenium purple; paraphyses filiform, branched, septate, tips slightly swollen 3–4 µm diam.; known from Europe under *Alnus incana* in shadowed, rich, moist soil and from China under conifers (Dissing 1985: 36, 37; Cao & al.1990: 283; Moyne & al.2010: 8)

9. Ascospores coarsely warted to tuberculate, rounded warts 1.5–3 µm high and semiglobular apiculi at the ends, 2–4 µm high and 3.5–5.5 µm across 10

9. Ascospores finely verrucose, warts angular to irregular up to 0.7 µm high, semiglobular apiculi at the ends absent ..... ***S. protea***
Apothecia 5–12 mm diam., cupulate to discoid, hymenium purple to dark purple; paraphyses filiform, slightly enlarged at apex, up to 6.5 µm diam.; known only from Czech Republic on sandy soil (Zhuang & Korf 1986: 380, Benkert 2005: 143, 151)

10. Apothecia dark purplish violet or blackish violet, ascospores (18–)19.5–22(–23) × (9.5–)11–12.5(–13) µm ..... ***S. amethystina***
Apothecia 4–20 mm diam., first cupulate then discoid; paraphyses filiform, unbranched, septate, tips swollen 4–5 µm diam.; known from Europe under *Salix, Alnus, Corylus,* and *Laurus* on sandy soil (Brummelen 1969: 225, Iglesias 2010: 35, 36)

10. Apothecia olive gray, olive brown, dull green to greyish green, ascospores 22–28 × 10–14(–15) µm ..... ***S. isoldae***
Apothecia 3–8 mm diam., cupulate when young, then flattened to discoid; paraphyses filiform, unbranched, septate, with swollen apex, clavate to capitate, 6–12 µm diam.; known only from Mexico on decayed wood.

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Scytinopogon caulocystidiatus and *S. foetidus* spp. nov., and five other species recorded from Brazil

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Abstract—Seven species of *Scytinopogon* in the Atlantic Forest of Brazil are described. *Scytinopogon caulocystidiatus* and *S. foetidus* are proposed as new species based on morphological and molecular data. Five other species are presented: *S. chartaceus*, *S. dealbatus* and *S. robustus*, originally described from Brazil; and *S. pallescens* and *S. scaber*, previously reported for Brazil. Illustrations of the basidiomata and microstructures, including SEM images of ornamented basidiospores, are provided for all taxa. Comparisons with morphologically similar taxa and a key to the seven species of *Scytinopogon* known to occur in Brazil are also presented.

Key words—coral fungi, *Hydnodontaceae,* neotropics, taxonomy, *Trechisporales*

Introduction

Scytinopogon Singer is a clavarioid genus that is mainly distributed in tropical and subtropical regions (García-Sandoval & al. 2004, Larsson & al. 2011). The genus comprises eight species (Corner 1970, Petersen 1988, Desjardin & Perry 2015) and is characterized by its light colored, densely branched basidiomata with flattened branches, monomitic hyphal system consisting of clamped, noninflated hyphae, usually 4-spored basidia, and slightly angular, hyaline basidiospores with verruculose-echinulate ornamentation (Corner 1950).

Scytinopogon was previously included in *Clavariaceae* Chevall. based on basidiome morphology (Corner 1950, 1970, García-Sandoval & al. 2004); however, it was also proposed as related to different taxa of *Hydnodontaceae* Jülich (Jülich 1981) or the "Thelephoroid" series (Corner 1950). The tough, coriaceous basidiomata in *Scytinopogon* support its removal from *Clavariaceae* (Jülich 1981); Larsson & al. (2011) and Birkebak & al. (2013) show a phylogenetic proximity of *Scytinopogon* to the corticioid genus *Trechispora* P. Karst. (*Trechisporales* K.H. Larss.). Morphological characters supporting the *Scytinopogon* + *Trechispora* clade are a monomitic hyphal system and clamped generative hyphae with subicular hyphae or context hyphae with ampulliform septa (Hibbett & al. 2007). The presence of calcium oxalate crystals is common in *Trechispora* but is a species-specific character (Jülich 1981). García-Sandoval & al. (2004) found these crystals in the basal mycelium hyphae of *Scytinopogon* species.

Reviews of previously reported species of *Scytinopogon* from Brazil were published by Corner (1953, 1966, 1970) for the Amazon and by Rick (1959, Rio Grande do Sul), Corner (1970, Rio de Janeiro), Petersen (1988, São Paulo), and Meijer (2006, 2008, Paraná) for the Atlantic Forest. These studies cited five species, but most lack complete descriptions.

Considering the wide distribution of *Scytinopogon* in tropical and subtropical regions, and with the goal of increasing what is known about the genus in the Atlantic Forest, this work provides detailed descriptions and illustrations of the seven *Scytinopogon* species recorded for Brazil: two new species (*S. caulocystidiatus*, *S. foetidus*); three species described first from Brazil (*S. chartaceus*, *S. dealbatus*, *S. robustus*); and two species originally described elsewhere (*S. pallescens*, *S. scaber*).

While this article was in preparation, Meiras-Ottoni & al. (2021) proposed synonymizing *Scytinopogon* under *Trechispora* based on ITS and 28S sequence analyses. Although we agree the two genera are phylogenetically related, we feel that additional DNA regions and species are needed before concluding that *Scytinopogon* and *Trechispora* are fully synonymous. We prefer to retain the present species in *Scytinopogon* until a more thorough revision of the group is conducted.

Material & methods

Morphological data

Field trips were conducted between January 2013 and August 2014 (with an additional expedition in January 2016) mostly during the rainy season in the states of

Rio Grande do Sul, São Paulo, and Santa Catarina. Whenever possible, macroscopic characters were studied from fresh specimens. Color codes (e.g., 2B19) are based on Kornerup & Wanscher (1978). Microscopic characters were observed from sections of dried basidiomata using an Olympus CX21 microscope and a 1000× immersion oil lens. Descriptive terms follow Corner (1947), Largent & al. (1977), and Vellinga & Noordeloos (2001). All microscopic structures were observed in water, 3% potassium hydroxide, Melzer's solution, and Congo red. Measurements were made in a solution of Congo red and 5% potassium hydroxide. Basidiospore measurements excluded ornamentation. At least twenty-five measurements were made of each microstructure. Q refers to the average basidiospore length/width ratio. The descriptions are based on all collections studied; the number of collections is shown in parentheses (s =) after each basidiospore measurement. Illustrations of microscopic features were based on digital photographs. Scanning electron microscopy (SEM) was conducted at the Laboratório Central de Microscopia Eletrônica (LCME/UFSC). Hymenophore fragments were removed from dried basidiomata, mounted on aluminum stubs using carbon adhesive tabs, coated with 30 nm of gold, and examined with a scanning electron microscope operating at 10 keV. Voucher material was deposited at the Universidade Federal de Santa Catarina, Florianópolis, Brazil (FLOR). The Material examined sections list specimens collected during the present work and the Additional specimens examined were from BPI, CGE, FLOR, INPA, JPB, K, MBM, PACA, RBGE, and URM (Thiers 2017). The Reference exsiccata studied section lists specimens of other taxa that were used for taxonomic comparison.

Genomic DNA extraction, PCR and Sequencing

Genomic DNA was extracted from dried material using a PowerPlant®Pro DNA Isolation Kit, following the manufacturer's protocol adapted for fungi. The internal transcribed spacer of ribosomal nuclear DNA (nrITS) region was amplified using the primers ITS1F and ITS4R (Dentinger & al. 2010) and the following cycling parameters: an initial denaturation at 94°C for 2 min; 40 cycles of 30 s at 94°C, 45 s at 55°C and 1 min at 72°C; and a final extension at 72°C for 7 min. The PCR products were purified using PEG (polyethylene glycol; Sambrook & al. 1989). Sanger sequencing was performed with a BigDye Terminator 3.1 Cycle Sequencing Kit, following the manufacturer's protocol, using the same primers cited above, at Fundação Oswaldo Cruz (Fiocruz), Minas Gerais, Brazil. The generated sequences and their respective chromatograms were manually inspected and edited with Geneious v.6.1.8 (Kearse & al. 2012).

Phylogenetic analyses

Specimens and GenBank accession numbers used in this study are shown in Table 1. Newly generated DNA sequences were combined with the available ITS sequences of *Scytinopogon* from GenBank, as well as sequences of *Brevicellicium exile* (H.S. Jacks.) K.H. Larss. & Hjortstam and *Trechispora stellulata* (Bourdot & Galzin) Liberta as the outgroup, to construct a final 32-sequence matrix. Alignments were generated using

TABLE 1. *Scytinopogon* and outgroup sequences used in the phylogenetic analyses. Newly generated sequences are set in bold font.

TAXON	VOUCHER	ORIGIN	GENBANK ACCESSION NUMBER
S. caulocystidiatus	**FLOR 56314**	**Brazil**	**MK458772**
S. chartaceus	**FLOR 56185**	**Brazil**	**MK458775**
S. dealbatus	**FLOR 56182**	**Brazil**	**MK458776**
	FLOR 56183	**Brazil**	**MK458777**
S. foetidus	**FLOR 56315**	**Brazil**	**MK458769**
S. havencampii	SFSUDED8300	São Tomé & Principe	KT253946
S. pallescens	**FLOR 56184**	**Brazil**	**MK458767**
	FLOR 56186	**Brazil**	**MK458766**
	FLOR 56187	**Brazil**	**MK458771**
	FLOR 56188	**Brazil**	**MK458774**
S. robustus	**FLOR 56179**	**Brazil**	**MK458770**
	FLOR 56190	**Brazil**	**MK458768**
S. scaber	**FLOR 56189**	**Brazil**	**MK458773**
Scytinopogon sp.	BAB5120	India	KT804576
	9P829	Taiwan	KF6795001
	0906RK610	Taiwan	KF6795051
	9P615	Taiwan	KF679498
	0906RK623	Taiwan	KF6795031
	9P1233	Taiwan	KF6795011
	0906RK71	Taiwan	KF6795021
	0906RK1023	Taiwan	KF6795061
	0906RK647	Taiwan	KF6795041
	9P79	Taiwan	KF6794991
Scytinopogon sp. 1	MEL2382623	Australia	KP012986
	MEL2382744	Australia	KP012927
	MEL2382716	Australia	KP012897
	MEL2382612	Australia	KP012977
Scytinopogon sp. 2	MEL2382992	Australia	KP012847
	MEL2382675	Australia	KP013038
	MEL2382987	Australia	KP012842
Brevicellicium exile	UV2022824	USA	KP814539
Trechispora stellulata	UC2022931	USA	KP814168

MAFFT v. 7 (Katoh & Standley 2013) according to E-INS–i criteria. Sequences were then manually corrected using the software MEGA v.7.0.14 (Tamura & al. 2013). Indels present in the nrITS datasets were recoded as binary characters following the "simple indel coding method" (SIC, Simmons & Ochoterena 2000), which was implemented in SeqState (Müller 2005). The resulting binary characters were joined in the final matrix as a distinct partition. The final alignments (as well the final topologies) were logged in TreeBase (http://purl.org/phylo/treebase/phylows/study/TB2:S22377). New sequences generated for this work were uploaded to GenBank (Sayers & al. 2009).

Maximum likelihood (ML) and Bayesian inference (BI) criteria were applied to the datasets, which were divided in three partitions for the ITS (ITS1/2, 5.8S and recoded indels). The best model of nucleotide evolution for each nucleotide partition was determined using BIC (Bayesian information criterion) with the software jModelTest v2.1.6 (Guindon & Gascuel 2003, Darriba & al. 2012). ML analyses were performed using the software RAxML v. 8.2.10 (Stamatakis 2014) available on the CIPRES portal (Miller & al. 2010, http://www.phylo.org/). The analysis first involved 100 ML searches, each starting from one randomized stepwise addition parsimony tree (command –f d), under a GTRGAMMA model, with all other parameters estimated by the software. To assess the reliability of the nodes, nonparametric bootstrapping replicates under the same model were computed, allowing the program to halt bootstrapping automatically with the autoMRE bootstrapping criterion. To plot the calculated bootstrap values on the branches, the command –fb was used. The BI was performed with the software Mr. Bayes v.3.2.6 (Ronquist & Huelsenbeck 2003), implemented in CIPRES Science Gateway 3.1. BI was performed using two independent runs, each starting from random trees, with four simultaneous independent chains, and performed 10,000,000 generations, keeping one tree every 1000th generation. Four rate categories were used to approximate the gamma distribution. Of all trees sampled, 20% were discarded as burn-in and checked by the convergence criterion (frequencies of average standard deviation of split <0.01) with Tracer v.1.6 (Rambaut & al. 2014), while the remaining were used to reconstruct a 50% majority-rule consensus tree and to estimate Bayesian posterior probabilities (BPP) of the branches. A node was considered strongly supported if it had a BPP ≥0.95 and/or BS ≥90% and moderately supported if it had a BPP ≥0.90 and/or BS ≥70%.

Phylogenetic results

Twelve new nrITS sequences from *Scytinopogon* were generated during this study. The best models of nucleotide substitution estimated for the partitions were TPM2uf+G for the combined ITS1/ITS2 and K80 for the 5.8s. The recovered tree topologies resulting from both routines were basically identical. This work shows the topology from the ML analyses, with both BPP and BS values (Fig. 1). *Scytinopogon scaber*, *S. caulocystidiatus* and *S. dealbatus* are early branches in the trees. Four other clades are formed by the remaining species.

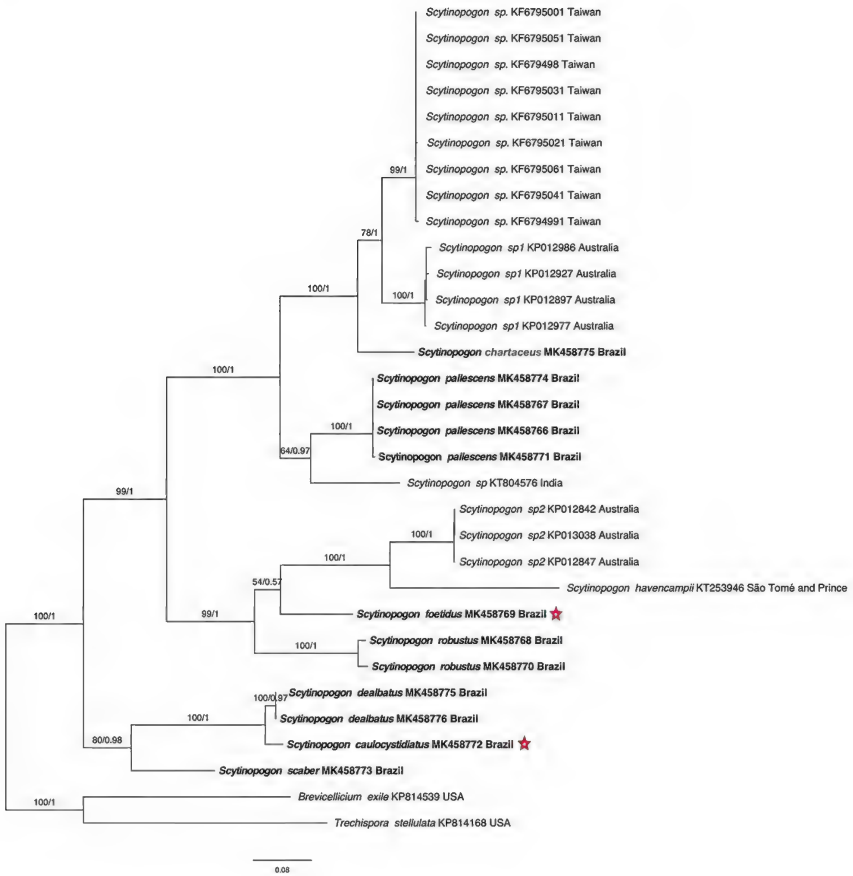
Scytinopogon sp. KF6795001 Taiwan
Scytinopogon sp. KF6795051 Taiwan
Scytinopogon sp. KF679498 Taiwan
Scytinopogon sp. KF6795031 Taiwan
Scytinopogon sp. KF6795011 Taiwan
Scytinopogon sp. KF6795021 Taiwan
Scytinopogon sp. KF6795061 Taiwan
Scytinopogon sp. KF6795041 Taiwan
Scytinopogon sp. KF6794991 Taiwan
Scytinopogon sp1 KP012986 Australia
Scytinopogon sp1 KP012927 Australia
Scytinopogon sp1 KP012897 Australia
Scytinopogon sp1 KP012977 Australia
Scytinopogon chartaceus MK458775 Brazil
Scytinopogon pallescens MK458774 Brazil
Scytinopogon pallescens MK458767 Brazil
Scytinopogon pallescens MK458766 Brazil
Scytinopogon pallescens MK458771 Brazil
Scytinopogon sp KT804576 India
Scytinopogon sp2 KP012842 Australia
Scytinopogon sp2 KP013038 Australia
Scytinopogon sp2 KP012847 Australia
Scytinopogon havencampii KT253946 São Tomé and Prince
Scytinopogon foetidus MK458769 Brazil
Scytinopogon robustus MK458768 Brazil
Scytinopogon robustus MK458770 Brazil
Scytinopogon dealbatus MK458775 Brazil
Scytinopogon dealbatus MK458776 Brazil
Scytinopogon caulocystidiatus MK458772 Brazil
Scytinopogon scaber MK458773 Brazil
Brevicellicium exile KP814539 USA
Trechispora stellulata KP814168 USA
0.08

Fig. 1. Consensus tree from Maximum likelihood (ML) analysis of *Scytinopogon* based on a dataset of 32 nrITS sequences rooted with the outgroup (*Brevicellicium exile* and *Trechispora stellulata*). Bayesian posterior probability (on the right of the "/") >0.7 and bootstrap values (on the left of the "/") >50% are shown. The twelve new sequences are highlighted in bold type. Red stars indicate the new taxa, *Scytinopogon caulocystidiatus* and *S. foetidus*.

In the analysis, the *Scytinopogon caulocystidiatus* sequence (FLOR 56314) is closely related to *S. dealbatus* (FLOR 56182, FLOR 56183) from Brazil (BS = 80, BPP = 0.98). Our molecular phylogeny (Fig. 1) confirms our morphological analyses that *S. caulocystidiatus* and *S. dealbatus* are distinct taxa.

Two *Scytinopogon robustus* sequences (FLOR 56190, FLOR 56179) clustered in a well-supported clade (BS = 99, BPP = 1) with the sequences

of *Scytinopogon foetidus*, *S. havencampii* (SSFU DEB8300) from São Tomé and Principe, and *Scytinopogon* sp. 2 from Australia.

The *Scytinopogon foetidus* sequence clustered in a weakly supported but resolved clade (BS = 54, BPP = 0.57) close to *S. havencampii* (SSFU DEB8300), suggesting that they are different species. This is supported by the morphological analysis, as discussed below.

The Brazilian *S. pallescens* sequences (FLOR 56184, FLOR 56186, FLOR 56187, FLOR 56188) clustered (BS = 64; BPP = 0.97) in a clade that included *Scytinopogon* sp. (BAB5120) from India. The clade including *Scytinopogon chartaceus* was strongly supported (BS = 100; BPP = 1). Sequences from *Scytinopogon* sp. (9P829, 0906RK610, 9P615, 0906RK623, 9P1233, 0906RK71, 0906RK1023, 0906RK647, 9P79) from Taiwan and *Scytinopogon* sp. 1 (MEL2382623, MEL2382744, MEL2382716, MEL2382612) from Australia were recovered as sister taxa of *S. chartaceus*.

Taxonomy

Scytinopogon caulocystidiatus A.N.M. Furtado & M.A. Neves, **sp. nov.** FIG. 2

MB 829606

Differs from *Scytinopogon dealbatus* by the presence of catenulate caulocystidia.

TYPE—Brazil. Santa Catarina: Florianópolis, Ilha do Campeche, Trilha do Morcego, 27°40′40″S 48°28′6″W, 24 III 2014, A.N.M. Furtado 460 (**Holotype**, FLOR 56314; GenBank 458772).

ETYMOLOGY—The epithet refers to the abundant catenulate caulocystidia.

BASIDIOMATA 35–70 mm tall, solitary, gregarious to densely caespitose, white (1A1), drying yellowish white (4A2) with reddish-brown (8D7) apices; branches subcylindric at first, becoming flattened, twisted, slightly subpruinose, 3.0 mm wide in the lower branches, tapering towards the apex, polychotomous below, di- or trichotomous towards the apex, branched three to five times, internodes gradually becoming smaller, apices subfusiform, acute, subterete, narrowly spathulate; STIPE cylindric, short, 10–20 × 3.0–5.0 mm. CONTEXT reddish brown (8DF), tough at stipe base; odor of ammonia; taste unrecorded.

BASIDIOSPORES 3.5–4.5 × 3.0–3.5 µm (Q = 1.06) (s = 2 specimens), subglobose, hyaline, uniguttulate, slightly angular, with diminutive spines, ≤0.5 µm long, slightly thick-walled, apex blunt, inamyloid; hilar appendage ≤0.5 µm. BASIDIA 20–29 × 4.5–6.0 µm, clavate, clamped; 2- or 4-spored, 3.5–5.0 µm long. CYSTIDIA in stipitipellis as caulocystidial hairs, 58–72 ×

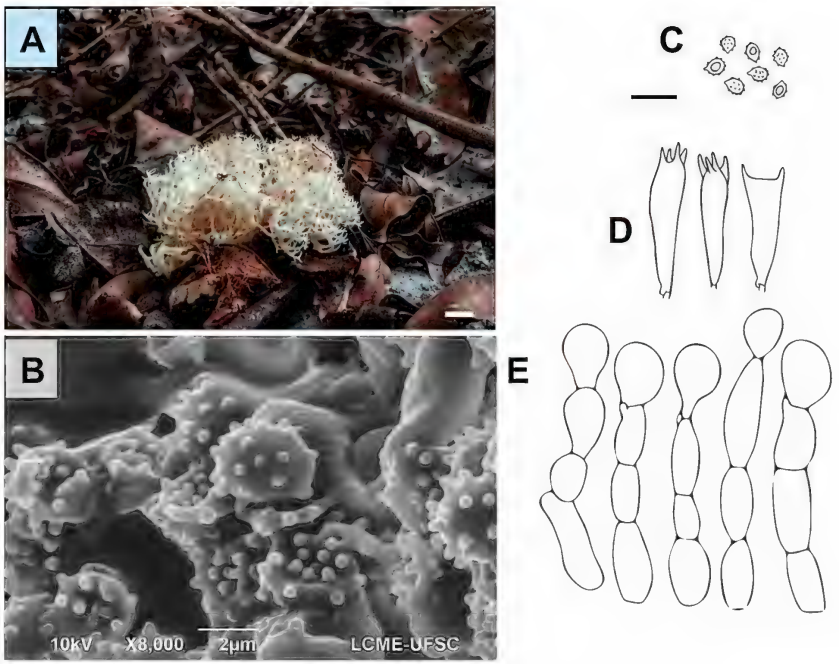

Fig. 2. *Scytinopogon caulocystidiatus* (FLOR 56314). A. Fresh basidiomata in situ; B, C. Basidiospores; D, Basidia; E. Capitate cystidial hairs of stipitipellis. Scale bars: A = 1 cm; C–E = 10 µm.

10–18 µm, formed by concatenation of narrowly utriform, capitate to sphaeropedunculate hyphae, smooth, thin-walled, clamped; peduncle when present 4.0 × 2.0 µm. Hymenium ≤62.5 µm thick, thickening upward, amphigenous, stratified into three layers, older basidia tortuous to collapsed, absent in stipe. Subhymenium ≤40 µm thick, constricted at the septa, hyphae 5.0 µm diam, thin-walled. Context with subparallel arranged hyphae 4.0–6.0 µm diam, cylindric, alternating with inflated hyphae 10–12 µm wide, ampulliform segments rare, 6.0–7.0 µm wide, thin-walled, clamped. Internal stipe hyphae 2.0–7.0 µm diam, irregularly inflated, pale yellow (1A2).

Ecology & distribution—On sandy soil in forest on marine sands. Known only from the type locality.

Additional material examined—**BRAZIL. Santa Catarina: Florianópolis**, Unidade de Conservação Ambiental Desterro - UCAD, 27°31′50″S 48°30′44″W, 8 I 2016, M.L. Vanegas-León 61 (FLOR 59324).

Comments—*Scytinopogon caulocystidiatus* is difficult to see in the field as its white basidiomata grow on a whitish, sandy substrate.

Scytinopogon caulocystidiatus and *S. dealbatus* have basidiomata that are the same size, shape, color, and consistency. Also, unlike most *Scytinopogon* species, both have an amphigenous hymenium. *Scytinopogon dealbatus* can be separated by its ellipsoid basidiospores and the absence of caulocystidia.

Besides the strong odor of ammonia, a diagnostic characteristic of this species is the cystidial stipitipellis, previously undescribed for *Scytinopogon* (Corner 1950, 1970, Petersen 1988, García-Sandoval & al. 2004).

Scytinopogon chartaceus (Pat.) R.H. Petersen, Mycologia 80: 574. 1988 [as 'chartaceum']. Fig. 3

Basidiomata 30–65 × 25–47 mm, solitary to gregarious, chalk-white (1A1), becoming grayish white (1B1), drying pale yellow (3A4), palmately forked from a flattened stipe immersed in soil, branching in a plane, twisted; branches flattened and narrowly spathulate, 2.0–6.0 mm wide in the lower branches, tapering towards the apex, polychotomous below, becoming

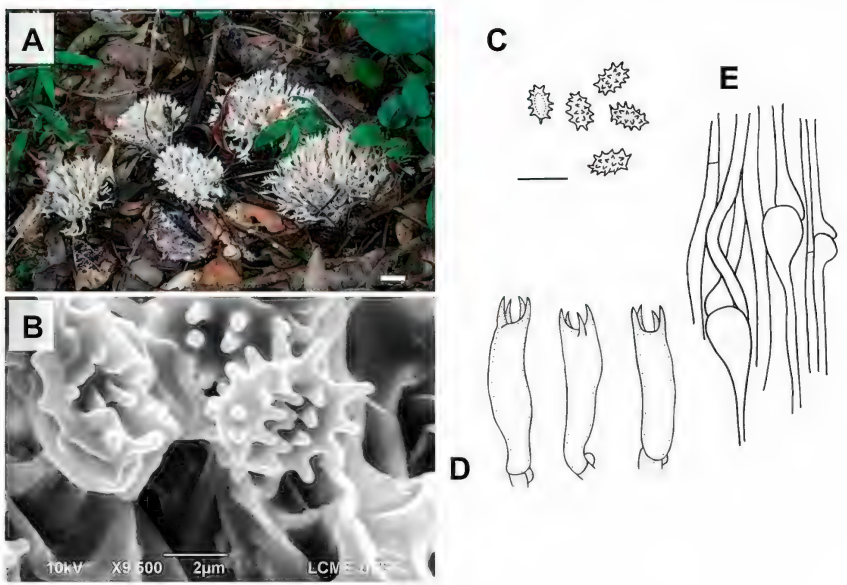

Fig. 3. *Scytinopogon chartaceus*. (FLOR 56185). A. Fresh basidiomata in situ; B, C. Basidiospores; D. Basidia; E. Context hyphae with ampulliform septa. Scale bars: A = 1 cm; C–E = 10 µm.

dichotomous, branched two to four times, internodes diminishing gradually; axils U-shaped, apices acute to blunt, subterete, suede-like above, smooth below; STIPE 15–30 × 7.0–15 mm, sometimes branched from the base, dilated and flattened below the branching points, arising from very scarce white mycelial strands on the soil. CONTEXT pale yellow (1A2), waxy, tough at the base of the stipe, drying cartilaginous; odor and taste unrecorded.

BASIDIOSPORES 6.0–8.0 × 3.0–4.5 µm (Q = 1.82) (s = 1 specimen), narrowly ellipsoid, hyaline, angular-echinulate, slightly thick-walled, spines 0.7–1.5 µm long, apex blunt, inamyloid; hilar appendage obscured by spore ornamentation. BASIDIA 25–32 × 6.0–8.0 µm, clavate, barrel-shaped, with homogeneous to minutely guttulate contents, clamped; 1–2-spored, 4.0–7.0 µm long. CYSTIDIA absent. HYMENIUM thickening upward, ≤100 µm thick, covering the undersides of the branches. SUBHYMENIUM c, 30 µm thick, hyphae 2.5–3.0 µm diam, thin-walled. CONTEXT with parallel arranged hyphae 3.5–4.0 µm diam, cylindric and long-celled, slightly thick-walled, ampulliform septa 5.5–8.0 µm diam, clamped. Surface of sterile base composed of repent hyphae 2.5–5.0 µm wide, smooth, thin-walled, clamped. Irregular crystals of calcium oxalate covering the contextual and basal mycelium hyphae.

ECOLOGY & DISTRIBUTION—On soil among litter, in Atlantic Forest. Known only from São Paulo (Campinas, Patouillard 1907; São Paulo, Petersen 1988), and Santa Catarina (present study), Brazil.

MATERIAL EXAMINED—**BRAZIL. SANTA CATARINA: Florianópolis**, Trilha para Naufragados, 27°49′4″S 48°33′37″W, 23 V 2014, A.N.M. Furtado 504 (FLOR 56185; GenBank MK 458775).

COMMENTS—The Brazilian type specimen, published as *Lachnocladium chartaceum* by Patouillard (1907), was not studied due to its poor condition. The identification of the specimen from Santa Catarina was based on the original protologue (Patouillard 1907) and the description of a specimen collected by Leif Ryvarden in São Paulo, Brazil, and identified as *S. chartaceus* by Petersen (1988).

Morphologically, *S. pallescens* is the most similar species; however, *S. pallescens* has larger internodes on its branches, the surface of the basidiomata is rugulose and subtomentose, and the well-developed basal mycelium is very compact (Corner 1950, 1970, Petersen 1988). *Scytinopogon chartaceus* has smaller internodes, basidiomata with a smooth surface, and scarce and loosely attached basal mycelium (Petersen 1984). Also, *S. pallescens* has nodulose to verrucose basidiospores and *S. chartaceus* has echinulate basidiospores with long spines (Reid 1962, Petersen 1988).

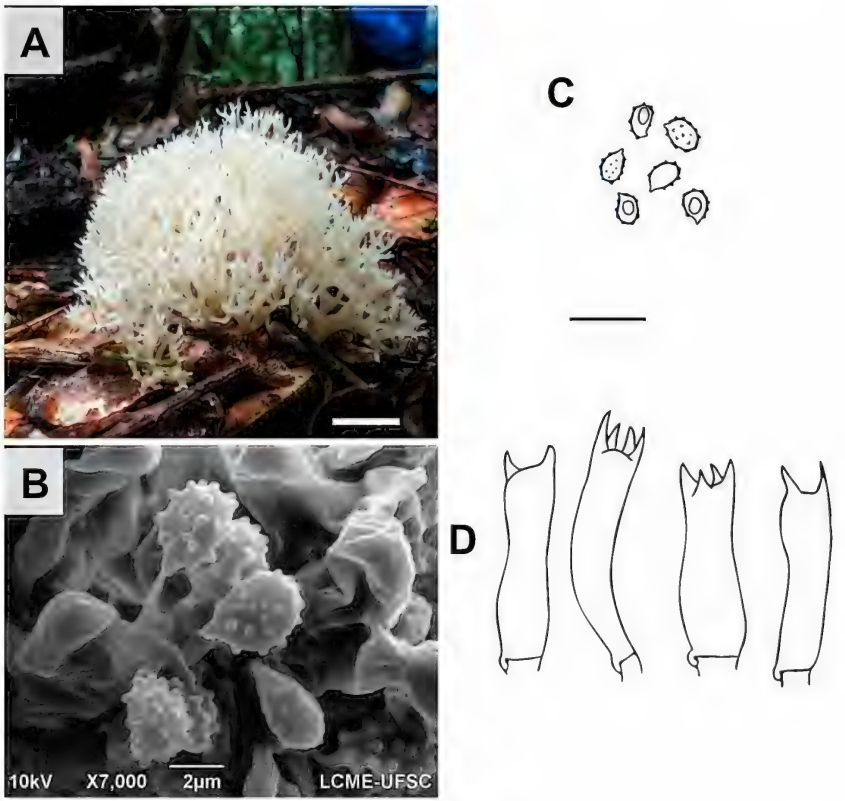

Fig. 4. *Scytinopogon dealbatus*. (FLOR 56183). A. Fresh basidiomata in situ; B, C. Basidiospores; D. Basidia. Scale bars: A = 1 cm; C–D = 10 µm.

Scytinopogon dealbatus (Berk.) Corner,
Beih. Nova Hedwigia 33: 89. 1970. Fig. 4

Basidiomata 55–75 mm tall, solitary to gregarious, white (1A1), the hymenium becoming pale yellow (1B3), drying to reddish brown (5C4); branching often polychotomous from the base, becoming dichotomous above, branched three to four times; branches 1.0–3.0 mm thick, ligulate, smooth; axils flat; apices concolorous with branches; stipe 2.0–3.0 mm thick, slightly distinct, white (1A1). Context gelatinous; taste and odor unrecorded.

Basidiospores 4.0–4.5 × 2.5–3.5 µm (Q = 1.39) (s = 2 specimens), ellipsoid, hyaline, echinulate to almost spineless, uniguttulate, warts ≤0.4 µm long, inamyloid; hilar appendage ≤1.0 µm, often sublateral. Basidia 21–29 × 5.0–7.0 µm, clavate, clamped; (2–)4-spored, 3.5–6.0 µm long. Cystidia

absent. Hymenium ≤150 µm thick, thickening upward, amphigenous, absent in stipe. Subhymenium ≤20 µm thick, composed of loosely interwoven hyphae ≤5.0 µm diam, thin-walled. Context hyphae subparallel, slightly agglutinated, 5.0–6.5 µm diam, walls thin, subgelatinous; ampulliform septa 6.6–13 µm diam, clamped.

Ecology & distribution—In the Atlantic Forest, this species is found on soil. In Brazil, it is known from Amazonas (type locality), Mato Grosso (Corner 1970), Paraná (Meijer 2006), São Paulo (Petersen 1988) and Rio Grande do Sul (Rick 1959; present study). It is also recorded for Bolivia, Panama (Corner 1970), and Venezuela (Petersen 1988).

Material examined—**BRAZIL. Rio Grande do Sul: Porto Alegre**, Universidade Federal do Rio Grande do Sul, Campus do Vale, 30°04′23.8″S 51°07′23.6″W, 1 IV 2014, E.P. Fazolino 176 (FLOR 56182; GenBank MK458776), E.P. Fazolino 177 (FLOR 56183, GenBank MK458777).

Additional specimens examined—**BRAZIL. Rio Grande do Sul: Panuré**, São Jerônimo, 1873, Spruce s.n. (K 135803, 135804, holotype of *Clavaria dealbata* Berk.); **São Leopoldo**, 1904, J.E. Rick s.n. (BPI 295129; PACA 17230, 17241, 17246, 17251, as *Lachnocladium dubiosum*); 1907, J.E. Rick s.n. (BPI 295385, 333169, 333170, 333171 as *Scytinopogon dubiosum* ad. int.); 1932, J.E. Rick s.n. (BPI 295383). **Mato Grosso: Chavantina**, 1 II 1968, E.J.H. Corner s.n. (RBGE 101765).

Comments—*Scytinopogon dealbatus* basidiomata resemble young *Scytinopogon scaber* but lack the erect habit and papillate branches (Petersen 1988). Also, the hymenium is present on both sides of the branches, contrary to other *Scytinopogon* species where the hymenium is unilateral. The gelatinous context is only known to occur in *S. dealbatus*. This character is rather common in *Ramaria* species; however, it is rarely reported in *Scytinopogon* (Petersen 1988).

Scytinopogon pallescens could be mistaken for a robust form of *S. dealbatus*. However, *S. pallescens* has flattened branches with the hymenium on one side of the branches, mycelia at the base of the stipe, angular-nodulose basidiospores, and lacks a gelatinous context (Corner 1950).

Petersen (1984, 1988) proposed transferring *S. dealbatus* to *Ramariopsis* based on the gelatinous context of the fresh basidiomata (a character never reported for *Scytinopogon*) and the ellipsoid and echinulate basidiospores rather than angular-nodulose basidiospores described by Corner (1970). However, Petersen (1988), who also studied a specimen from Venezuela collected by Roy Halling and identified as *S. dealbatus*, agreed that the species shares more characters with *Scytinopogon* than with *Ramariopsis*, especially because *S. dealbatus* lacks the dextrinoid reaction characteristic of *Ramariopsis* and not found in *Scytinopogon*.

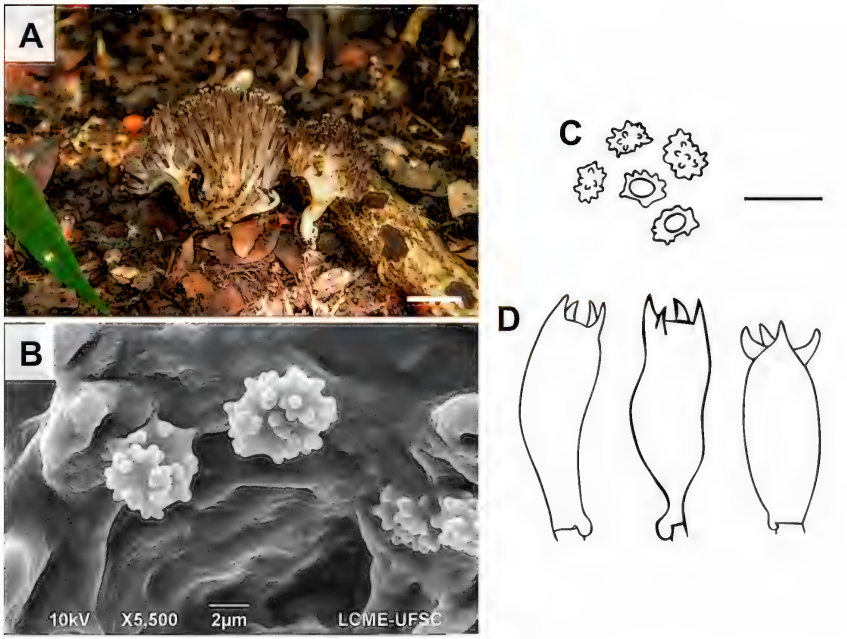

Fig. 5. *Scytinopogon foetidus*. (FLOR 56315).
A. Fresh basidiomata in situ; B, C. Basidiospores; D. Basidia.
Scale bars: A = 1 cm; C–D = 10 µm.

Scytinopogon foetidus A.N.M. Furtado & M.A. Neves, **sp. nov.** Fig. 5

MB 829605

Differs from *Scytinopogon havencampii* by its 4-spored basidia, its slightly concave ellipsoid basidiospores, its ampulliform septa, its strong putrid odor, and by the presence of calcium oxalate crystals.

Type—Brazil. Santa Catarina: Florianópolis, Costão do Santinho, Morro das Aranhas, 27°47′66″S 48°38′18″W, 27 I 2014, A.N.M. Furtado 423 (**Holotype**, FLOR 56315; GenBank MK458769).

Etymology—The epithet refers to the strong, unpleasant odor of the fresh basidiomata.

Basidiomata 25–55 mm tall, gregarious, pale grayish beige (4C2), becoming reddish brown (8E6) to deep brown (8F5) upward, the apices pure white (1A1), palmately branched from a flattened stipe, branching in one plane, sometimes twisted, subpruinose; branches cylindric to flattened and narrowly spathulate, 3.0–4.0 mm wide in the lower branches, tapering

towards the apex, polychotomous below, becoming dichotomous, branched three to four times, narrowly U-shaped, flattened below the branching points, internodes gradually becoming smaller, apices blunt, subterete, narrowly ligulate; STIPE 8.0–15 × 2.0–6.0 mm, rarely branched from the base, pale grayish beige (4C2). CONTEXT pale yellow (1A2), slightly viscid, tough at the base of the stipe; odor strong and putrid; taste unrecorded.

BASIDIOSPORES 5.0–6.5 × 3.0–4.0 µm (Q = 1.52) (s = 1 specimen), ellipsoid, the inner side slightly applanate to slightly concave, hyaline, finely verrucose, thin-walled, warts 0.4–0.6 µm long, apex blunt, inamyloid; hilar appendage small. BASIDIA 23–28 × 7.0–9.0 µm, clavate, barrel-shaped, clamped; 4-spored, 3.0–5.0 µm long. CYSTIDIA absent. HYMENIUM ≤32.5 µm thick, absent in stipe. SUBHYMENIUM ≤50 µm thick, with loosely interwoven hyphae, 3.5–5.0 µm diam, thin-walled. CONTEXT with subparallel arranged hyphae 3.5–8.0 µm diam, thin-walled, constricted at the septa, ampulliform septa 5.0–6.0 µm diam, clamped. Surface of stipe composed by a trichodermal pellis, with cylindric hyphae up to 3.0 µm diam, slightly thick-walled, clamped. Crystals of calcium oxalate in needle clusters covering the cortical hyphae from the stipe.

ECOLOGY & DISTRIBUTION—On soil in forest, perhaps also lignicolous. Known only from the type locality.

COMMENTS—Given that many basidiomata in *Scytinopogon* are white, *S. foetidus* and *S. robustus* appear similar in their grayish-purple coloration. *Scytinopogon robustus*, however, is slenderer and drier, with flattened branches and a unilateral hymenium (Corner 1970). It also has inflated hyphae and lacks the putrid odor and the calcium oxalate crystals in the stipe cortex.

Another pigmented species, *S. havencampii* Desjardin & B.A. Perry, described from Príncipe Island, Africa, differs in its cylindric, orangish-white stipe, 2-spored basidia with long sterigmata, ellipsoid, nonconcave basidiospores, indistinct odor, and absence of ampulliform septa and calcium oxalate crystals (Desjardin & Perry 2015). The molecular phylogeny also supports *S. foetidus* and *S. havencampii* as distinct species, but closely related species and in the same clade (FIG. 1).

Another pigmented species, *Scytinopogon echinosporus* (Berk. & Broome) Corner, known from Sri Lanka and Java, differs in its pale purple, often flattened branches with dark violet-brown tips, ellipsoid to angular basidiospores, 4-spored basidia, and inflated (≤12 µm diam) hyphae.

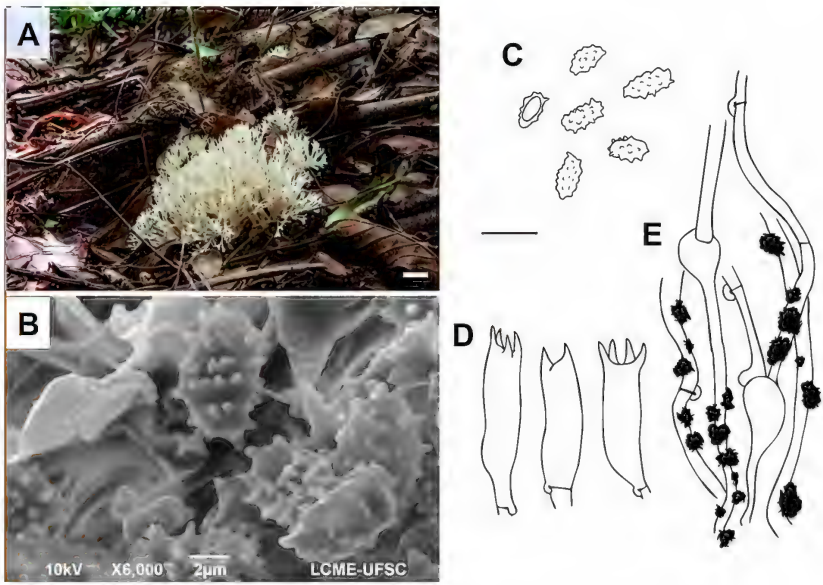

Fig. 6. *Scytinopogon pallescens*. (FLOR 56184). A. Fresh basidiomata in situ; B, C. Basidiospores; D. Basidia; E. Context hyphae with ampulliform septa. Scale bars: A = 1 cm; C–E = 10 µm.

Scytinopogon pallescens (Bres.) Singer, Lloydia 8(3): 139. 1945. Fig. 6

Basidiomata 40–110 mm tall, solitary, gregarious or densely caespitose, chalk-white (1A1) when young, pale yellow (1A2) in age, not changing when dried, palmately branched from a flattened stipe immersed in the soil, branching four to six times in one plane but twisted; branches slightly rugulose, flattened and narrowly spathulate, the upper side of the branches minutely subtomentose, 3.0–5.0 mm wide in the lower branches, tapering towards the apex, polychotomous below, becoming dichotomous, internodes becoming gradually longer; apices white (1A1), acute to blunt, subulate or subterete, narrowly ligulate; stipe 15–45 × 2.0–4.0 mm, sometimes branched from the base, dilated and flattened below the branch nodes, arising from compact mycelial strands in the soil. Context pale yellow (1A2), slightly coriaceous, tough at the base of the stipe; odor unpleasant; taste unrecorded.

Basidiospores 6.0–7.5 × 3.0–4.5 µm (Q = 1.96) (s = 5 specimens), narrowly ellipsoid, hyaline, angular-nodulose, finely verrucose, slightly thick-walled, warts 0.3–0.6 µm long, apex blunt, inamyloid; hilar appendage small. Basidia 25–32 × 6.0–8.0 µm, clavate, finely granular-vacuolate, clamped; 2–4-spored, 4.0–5.0 µm long. Cystidia absent. Hymenium ≤40 µm thick,

thickening upward, ≤250 µm thick, covering the underside of the branches. Subhymenium ca. 30 µm thick, composed of loosely interwoven hyphae, 2.5–5.0 µm diam, thin-walled. Context compact, with parallel arranged hyphae 3.5–4.0 µm diam, cylindric, with ampulliform septa 5.0–6.0 µm diam, slightly thick-walled, clamped. Surface of sterile base composed of a trichodermal pellis, hyphae 1.5–3.0 µm diam, smooth, thin-walled, clamped. Crystals of calcium oxalate in rosettes, covering the hyphae in the context and basal mycelium.

Ecology & distribution—In the Atlantic Forest, this species is found on soil and is possibly lignicolous. In Brazil, it is known from Amazonas, Mato Grosso, Pará, Paraná, Rio de Janeiro, Rio Grande do Sul (Corner 1953, 1966, 1970; Meijer 2006) and Santa Catarina (present study). It is also known from Burma, Cameroon, Congo (type locality), Cuba, Japan, Java, Madagascar, Malaysia, Mauritius, Nigeria, Panama, Sumatra, the Philippines, Solomon Islands, Uganda, the USA (Corner 1950, 1966, 1970), and India (Thind 1961; Dutta & al. 2012).

Material examined—**BRAZIL. Santa Catarina: Florianópolis**, Lagoa do Peri, Trilha da Cachoeira, 27°74′41″S 48°52′04″W, 15 II 2014, A.N.M. Furtado 441 (FLOR 56187; GenBank MK458771); 19 III 2014, A.C. Magnago 974 (FLOR 56186; GenBank MK458766); Universidade Federal de Santa Catarina, Campus Trindade, Depto de Botânica, 27°60′17″S 48°52′50″W, 26 III 2013, A.N.M. Furtado 304 (FLOR 56184; GenBank MK458767); 14 IV 2014, A.N.M. Furtado 488 (FLOR 56188; GenBank MK458774); M.A. Neves 588 (FLOR 56197).

Additional specimens examined—**BELIZE**, 2002, P.J. Roberts s.n. (K 109202, 109203, 109237). **BRAZIL. Paraíba**: Mataraca, 06 VI 2011, F. Wartchow s.n. (JPB 45094). **Pernambuco**: Recife, Parque Estadual de Dois Irmãos, 13 VIII 1954, O.S. Silva n.n. (URM 876); Vitória de Santo Antão, Itamatamirim, 17 IX 1954, S.J. Silva n.n. (URM 1071). **Rio Grande do Sul**: no location, 1925, J.E. Rick s.n. (BPI 295379, 333159, 333160, 333162, 333164, 723389, as *Clavaria pteruloides* Pat. & Gaillard), 1907, J.E. Rick s.n. (PACA 17243, as *Lachnocladium moelleri* Henn.); São Leopoldo, 1925, J.E. Rick s.n. (BPI 295379, 333159, 333160, 333162, 333164, 723389). **MALAYSIA. Malaya**: Pahang, 25 XI 1930, E.J.H. Corner s.n. (BPI 295368).

Comments—*Scytinopogon pallescens* is morphologically highly variable and a common species in tropical and subtropical regions (Corner 1970).

Scytinopogon pallescens is easily recognized macroscopically by its chalk-white basidiomata with flattened branches. Microscopically, it has hyaline ellipsoid, angular-echinulate basidiospores, and uninflated, non-mucilaginous hyphae throughout the basidioma (Corner 1950). Some of our collections had basidiospores with such subtle angles that they appeared ellipsoid. In addition, the specimens have chalk-white basal mycelia that divide palmately before reaching the surface of the substrate.

Corner (1970) referred many Brazilian collections to *Scytinopogon angulisporus* (Pat.) Corner, including several specimens from Rio Grande do Sul that Petersen (1984) redetermined as *S. pallescens*. *Scytinopogon angulisporus* is no longer accepted in *Scytinopogon*, since its type specimen is conspecific with *Clavulina connata* (Berk.) Corner (Petersen 1984).

Scytinopogon chartaceus is quite similar to *S. pallescens*, in both color and morphology of the basidioma; however, *S. chartaceus* has more strongly echinulate basidiospores. This ornamentation is unusual for most *Scytinopogon* species, which are normally nodulose-warted with cushion-shaped warts (Petersen 1988).

Scytinopogon robustus (Rick) Corner, Beih. Nova Hedwigia 33: 91. 1970. FIG. 7

BASIDIOMATA 23–35 mm tall, solitary or caespitose, pale grayish (19B2), drying pale yellow (3A4), subfragile, flattened; branches flattened to subcylindric, bifurcate with slightly compressed axils, branched three times, subacute, mostly dichotomous, internodes irregular, diminishing gradually towards the apex; apices grayish violet (15E5), subulate,

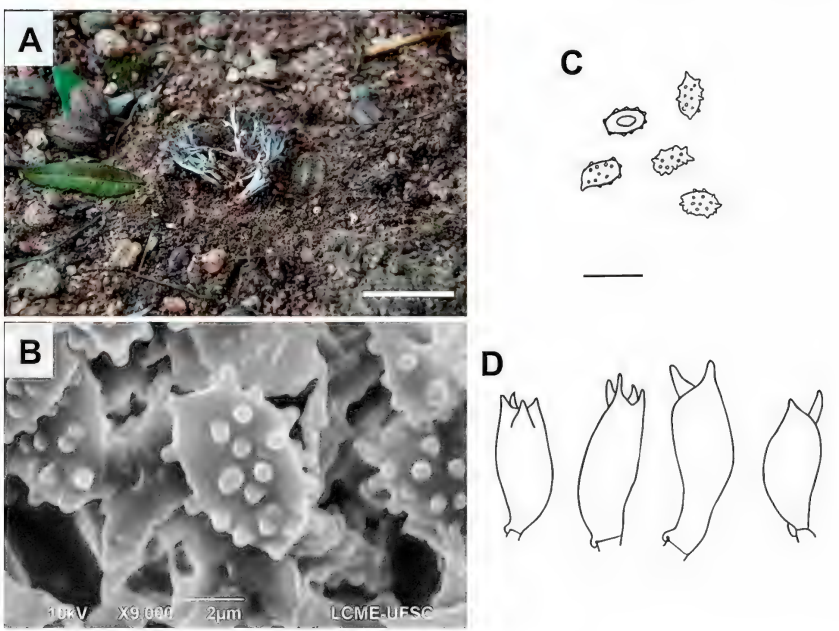

FIG. 7. *Scytinopogon robustus*. (FLOR 56190).
A. Fresh basidiomata in situ; B, C. Basidiospores; D. Basidia.
Scale bars: A = 1 cm; C–D = 10 µm.

sometimes blunt, subcristate to subpalmate; STIPE 9.0 × 2.0 mm, white to pale grayish (19B2), smooth, cylindric to flattened, coriaceous-fibrous. CONTEXT hollow; odor and taste not distinctive.

BASIDIOSPORES 6.0–6.5 × 3.5–4.0 µm (Q = 1.53) (s = 3 specimens), ellipsoid, hyaline, angular-nodular, slightly echinulate, slightly thick-walled, warts 0.4–0.8 µm long, inamyloid; hilar appendage obscured by spore ornamentation. BASIDIA 22–31 × 7.0–10 µm, clavate, barrel-shaped, clamped; (2–)4-spored, 3.0–5.0 µm long, homogeneous to minutely guttulate. CYSTIDIA absent. HYMENIUM ≤37.5 µm thick, covering the undersides of the branches. SUBHYMENIUM c. 20 µm thick, hyphae 3.0–3.5 µm diam, slightly inflated, clamped. CONTEXT with subparallel arranged hyphae 6.0–23 µm diam, inflated, thin-walled, slightly constricted at the septa, clamped. Surface of sterile base covered by repent hyphae ≤3.0 µm diam, smooth, hyaline, clamped; medullary basal hyphae 12–15 µm diam.

ECOLOGY & DISTRIBUTION—In the Atlantic Forest, *S. robustus* occurs on soil among litter. In Brazil, it is known from Paraná (Meijer 2006), Rio de Janeiro (Corner 1970), Rio Grande do Sul (type locality, Rick 1931, 1959), and Santa Catarina (present study). It is also known from Puerto Rico (Corner 1970) and Mexico (García-Sandoval & al. 2004).

SPECIMENS EXAMINED—**BRAZIL. SANTA CATARINA: Florianópolis**, Morro da Lagoa, Trilha do Jipe, 27°59′43″S 49°47′83″W, 23 I 2013, A.N.M. Furtado 422 (FLOR 56190; GenBank MK548768); Costão do Santinho, Morro das Aranhas, 27°47′66″S 48°38′18″W, 27 I 2014, A.N.M. Furtado 431 (FLOR 56179; GenBank MK458770). **SÃO PAULO: Caraguatatuba,** Serra do Mar, 19 I 2016, F.T.F. Linhares 144a (FLOR 59329).

ADDITIONAL SPECIMENS EXAMINED—**BRAZIL. RIO GRANDE DO SUL**: Parecí Novo, 1935, J.E. Rick s.n. (PACA 12457, holotype).

COMMENTS—Although our collection is small in size and has fragile basidiomata, *Scytinopogon robustus* can reach 50–100 mm tall (Rick 1931, García-Sandoval & al. 2004). However, the epithet refers to the size of the basidiospores, which are larger than the spores of other *Scytinopogon* species.

Scytinopogon pallescens, a widespread species, looks like a pale form of *S. robustus*; however, *S. pallescens* has larger basidiospores (5.5–7.0 × 3.5–4.0 µm) and its hyphae are not inflated (occasionally ≤10 µm diam) (Corner 1950, 1970, García-Sandoval & al. 2004).

Among the known species of *Scytinopogon*, only *S. robustus* and *S. echinosporus* have inflated hyphae (Corner 1970). *Scytinopogon echinosporus* has basidiomata with light brown apices and smaller basidiospores (4.5–5.5 × 3.5 µm, García-Sandoval & al. 2004).

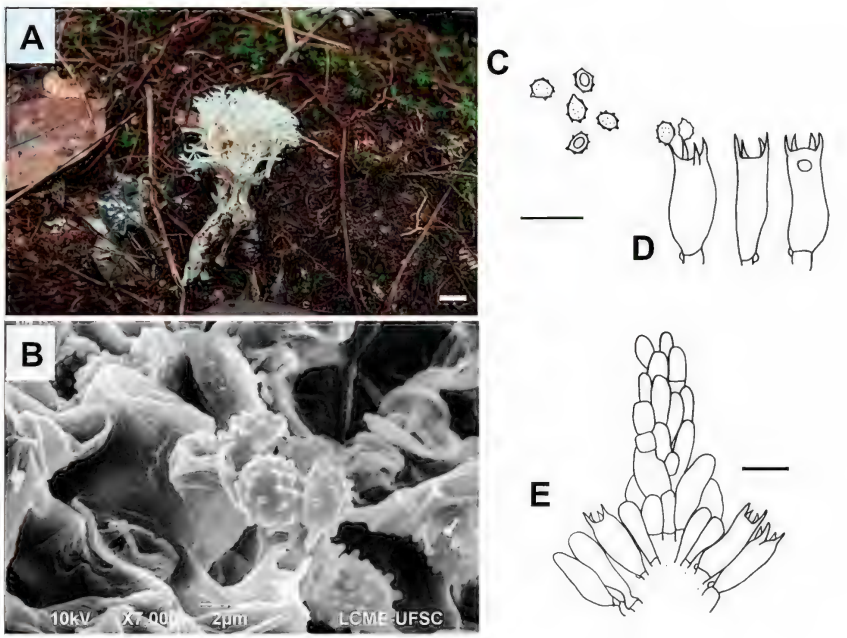

Fig. 8. *Scytinopogon scaber*. (FLOR 56189). A. Fresh basidiomata in situ; B, C. Basidiospores; D. Basidia; E. Context hyphae with ampulliform septa. Scale bars: A = 1 cm; C–E = 10 µm.

Scytinopogon scaber (Berk. & M.A. Curtis) D.A. Reid, Persoonia 2(2): 161. 1962. Fig. 8

Basidiomata 95 mm tall, solitary to scattered, white (1A1), slightly translucent to slightly pinkish close to the stipe, the apices concolor, branched; branches in one plane, becoming inclined and horizontal, flattened and narrowly spathulate, polychotomous below, becoming dichotomous, internodes spaced, subterete, slightly expanded at the axils, the underside developing minute spines or papillae (these scattered at first, then crowded and concrescent), entire or slightly dentate, irregular, apices ligulate; stipe 35 × 7.0 mm, dilating 3.0 mm wide upward. Context rather dry, firm; odor and taste absent.

Basidiospores 3.0–4.0 × 2.5–3.5 µm (Q = 1.26) (s = 1 specimen), broadly ellipsoid, hyaline, slightly angular, echinulate, warts 0.2–0.5 µm long, inamyloid; hilar appendage obscured by spore ornamentation. Basidia 15–18 × 4.5–5.5 µm, clavate, finely granular-vacuolate, clamped; 4-spored, 2.0–4.0 µm long. Cystidia absent. Hymenium ≤20 µm thick, thickening

upward, amphigenous, covering the undersides of the branches, sterile on the hypogenous region. Subhymenium ≤15 µm thick, hyphae 2.5–5.0 µm diam, thin-walled. Context with parallel arranged hyphae 3.5–4.0 µm diam, cylindric, slightly thick-walled, inner hyphae 8.0–12 µm diam, not inflated, clamped. Surface of sterile base with cylindric repent hyphae 3.0 µm diam, disarticulated, slightly thick-walled.

Ecology & distribution—In the Atlantic Forest, this species occurs on soil. It was previously reported for Brazil (without any details of localities or specimens) by Corner (1970), and here we record it for Santa Catarina. It is also known from Fiji (type locality), Brunei (Corner 1970), and Mexico (Ramírez-Lopes & al. 2012).

Material examined—**BRAZIL. Santa Catarina: Santo Amaro da Imperatriz**, Hotel Plaza Caldas da Imperatriz, Trilha da Pousada, 27°70′39″S, 48°80′37″W, 10 IV 2014, A.N.M. Furtado 483 (FLOR 56189; GenBank MK548773).

Additional specimens examined—**BRUNEI.** 1959, E.J.H. Corner s.n. (K 69072), 1992, B.M. Spooner s.n. (K 27130).

Comments—Originally described from Fiji, *Scytinopogon scaber* is diagnosed by its small, echinulate basidiospores and branched, clavarioid, distinctly papillate basidiomata (Ramírez-Lopes & al. 2012).

The collection from Santa Catarina is quite similar to Corner's collection from Brunei, except for some hyphae in the context that are broader in the Brazilian specimen (2.0–3.5 µm diam on Corner's specimen).

Scytinopogon papillosus Corner, the only other *Scytinopogon* species with a papillate hymenophore (Corner 1970), can be distinguished by its reddish basidiomata, very strongly inflated hyphae (3.0–25[–30] µm diam), and larger (4.0–4.5 × 2.7–3.5 µm) ellipsoid basidiospores (Corner 1970). *Scytinopogon papillosus* is known only from Bolivia, from Singer's collection in Corner (1970). Unfortunately, the type collection was not found so our comparison was based on Corner's protologue.

Key to *Scytinopogon* species in Brazil

1. Hymenophore becoming more or less minutely papillate or hydnoid ..... ***S. scaber***
1. Hymenophore smooth 2
2. Basidiomata light brown to reddish brown when fresh 3
2. Basidiomata pure white to pale yellow when fresh 4
3. Basidiomata slender with flattened branches, context dry; context hyphae inflated to 6.0–23 µm diam ..... ***S. robustus***
3. Basidiomata robust with cylindric to flattened and narrowly spathulate branches, context viscid; context hyphae 3.5–8 µm diam ..... ***S. foetidus***

4. Basidiomata subfragile, reddish brown when dry; basal mycelium absent 5
4. Basidiomata more robust, pale yellow when dry; basal mycelium present 6
5. Basidiospores subglobose; cystidial hairs on stipitipellis ..... ***S. caulocystidiatus***
5. Basidiospores ellipsoid; no cystidial hairs on stipitipellis ..... ***S. dealbatus***
6. Basal mycelium abundant and very compact, crystals present, insoluble in KOH; basidiospores nodulose, finely verrucose ..... ***S. pallescens***
6. Basal mycelium scant and loosely attached, crystals absent; basidiospores truly echinulate ..... ***S. chartaceus***

Reference Exsiccata Studied—***Scytinopogon echinosporus***: **SOLOMON ISLANDS**. 1967. E.J.H. Corner s.n. (RBGE 101775). **INDONESIA**. 1996, R.F. Ellen s.n. (K 45815).

Scytinopogon papillosus: **BOLIVIA**. 17 III 1956, R. Singer B 2100, B 2100 A (CGE, holotype).

Discussion

The Brazilian Atlantic Forest harbors a great diversity of macrofungi and the continual description of new species in this area emphasizes the importance of studying and preserving this biome. This work expands what is known about clavarioid fungi in the Atlantic Forest by providing detailed descriptions and illustrations for seven *Scytinopogon* species and adding two new species. to both the region and the world.

This work also presents a more robust phylogeny for *Scytinopogon* generated from nrITS sequences of six out of eight known species, supporting *Scytinopogon caulocystidiatus* and *S. foetidus* as new, independent species and confirming the morphological differences between them and the rest of the genus.

Scytinopogon was historically classified in *Clavariaceae*, despite the proposed relationship with *Hydnodontaceae* and thelephoroid fungi. However, the results obtained by Larsson & al. (2011) and Birkebak & al. (2013) indicate *Scytinopogon* is related to *Trechispora*. Nevertheless, to clarify the classification of *Scytinopogon* in *Hydnodontaceae* (*Trechisporales*), a more comprehensive study with more samples and more molecular markers is needed.

We have also shown that despite its being rarely documented, *Scytinopogon* is both abundant and widespread in the tropics and subtropics.

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Brykendrickia catenata gen. & sp. nov. from India

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Abstract—A new hyphomycete genus and species, *Brykendrickia catenata*, collected on decaying culms of bamboo species from Indian forests, is described and illustrated. *Brykendrickia catenata* is the type species for a new monotypic genus possessing sporodochial conidiomata. Conidiogenous cells are polyblastic, rarely monoblastic, cylindrical, and hyaline to subhyaline. Conidia are loosely cheiroid, blastocatenate, and produce branches of doliiform to oblong, botuliform, globose or subglobose, sub-hyaline to light grey cells.

Key words—asexual fungi, systematics, taxonomy

Introduction

India is one of the richest reservoirs of biodiversity in Asia. During ongoing surveys on wood inhabiting fungi, many new ascomycetes, basidiomycetes, and asexual fungi (especially hyphomycetes) have recently

been described (Adamčík & al. 2015; Buyck & al. 2017; Prasher & Verma 2014, 2015a,b,c; Prasher 2015; Sushma & al. 2019; Verma & al. 2019). Here we describe and illustrate a conidial fungus collected on dead and fallen bamboo culms from Mandi district, Himachal Pradesh. The fungus could not be morphologically accommodated in any of the published hyphomycete genera (Ellis 1971, 1976; Subramanian 1971; Matsushima 1975, 1983, 1985, 1989, 1993, 1995; Carmichael & al. 1980; Castañeda-Ruiz 1985, 1986a,b, 1987, 1988; Castañeda-Ruiz & Kendrick 1990a,b, 1991; Seifert & al. 2011; Punithalingam & Spooner 2011). Therefore, a new genus, *Brykendrickia,* is proposed.

Materials & methods

Decaying culms of *Bambusa* sp. were collected, placed in paper bags, and taken to the laboratory. The specimen was mounted in 0.01% cotton blue in lactophenol, and 2% congo red in 50% ammonia (Kirk & al. 2008) and examined under a Matrix VL-Z60 stereo trinocular microscope and VRS-2f compound microscope. For scanning electroscopy, material was vacuum-dried in an oven for 24 hours, mounted and sputtered with gold for 60 seconds, and photographed in a JEOL JSM–6100 scanning electron microscope. The specimens were deposited in the herbarium of the Department of Botany, Panjab University, Chandigarh, India (PAN). Repeated attempts to culture the fungus failed on PDA (2% agar broth, potato dextrose agar), oatmeal agar, malt extract agar (MEA), and a solidified glucose peptone medium (glucose 10 g/l, peptone 2 g/l, KH_2PO_4 1 g/l, $MgSO_4.7H_2O$ 0.5g/l. and agar 20 g/l in 1000 ml H_2O with chips of host).

Taxonomy

Brykendrickia Rajn.K. Verma, Prasher, Rajeshk., Sushma, A.K. Gautam & R.F. Castañeda,

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Differs from *Brachyconidiellopsis* and *Brachyconidiella* by its rudimentary, pustulate conidiomata and its undifferentiated conidiophores.

Type species— *Brykendrickia catenata* Rajn.K. Verma & al.

Etymology—Latin, *Brykendrickia*, in honor of Prof. Bryce Kendrick, who has contributed immensely to hyphomycete taxonomy.

Conidial fungi, hyphomycetes. Conidiomata sporodochial, rudimentary, pustulate. Mycelium mostly superficial, composed of septate, rarely branched, hyaline to subhyaline (pale greyish) hyphae forming mats. Conidiophores undifferentiated. Conidiogenous cells polyblastic, rarely monoblastic, terminal, discrete or integrated, sympodially elongated, cylindrical or clavate, hyaline to subhyaline. Conidial secession schizolytic. Conidia loosely

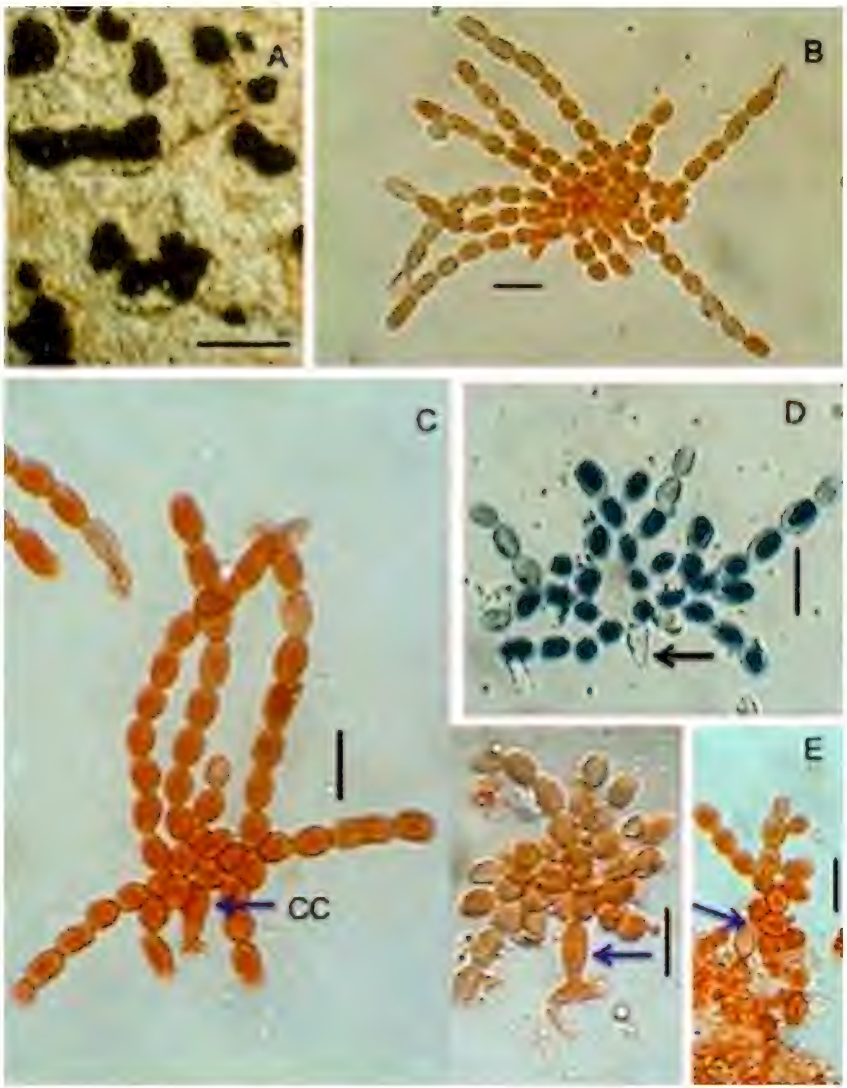

Fig. 1. *Brykendrickia catenata* (holotype, PAN 32735).
A. Sporodochia on natural substratum;
B–E. Conidia with conidiogenous cell (arrows showing basal cell).
Scale bars: A = 1000 µm; B–E = 10 µm.

cheiroid, blastocatenate, composed of branches with doliiform to oblong, botuliform, globose or subglobose, hyaline or subhyaline, smooth cells.

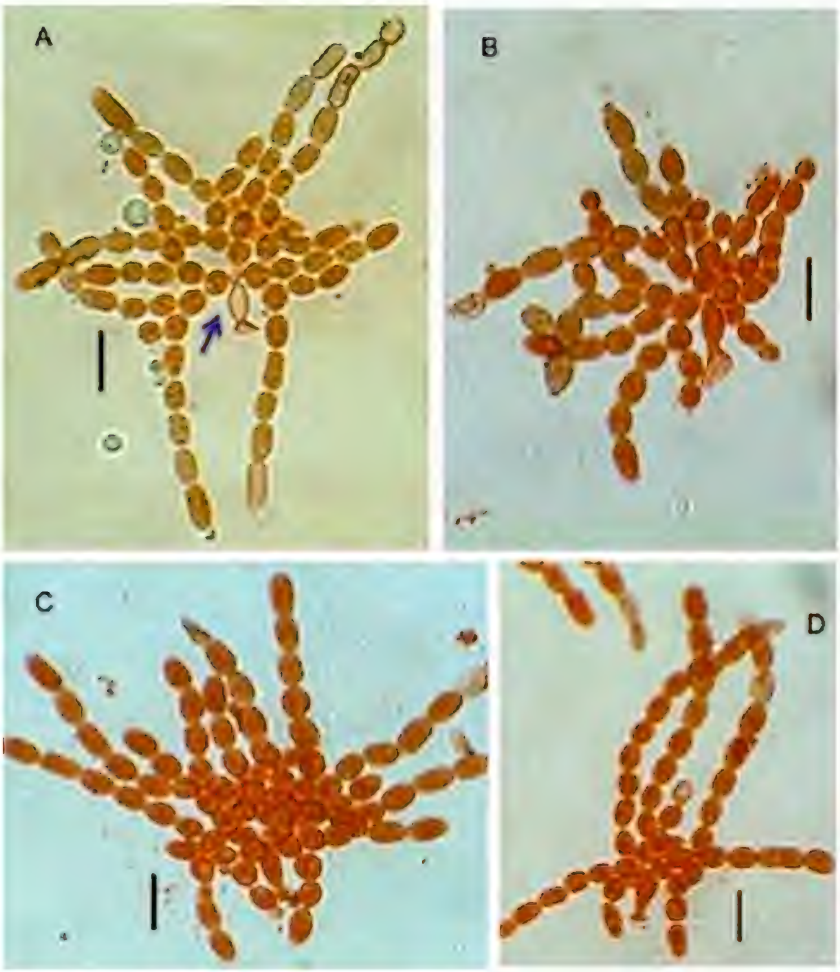

Fig. 2. *Brykendrickia catenata* (holotype, PAN 32735).
Conidia with conidiogenous cell (arrow).
Scale bars = 10 µm.

Brykendrickia catenata Rajn.K. Verma, Prasher, Rajeshk., Sushma, A.K. Gautam & R.F. Castañeda, Figs 1–4

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Differs from *Brachyconidiellopsis* and *Brachyconidiella* species by its rudimentary, pustulate conidiomata and its undifferentiated conidiophores, which are reduced to discrete or integrated conidiogenous cells.

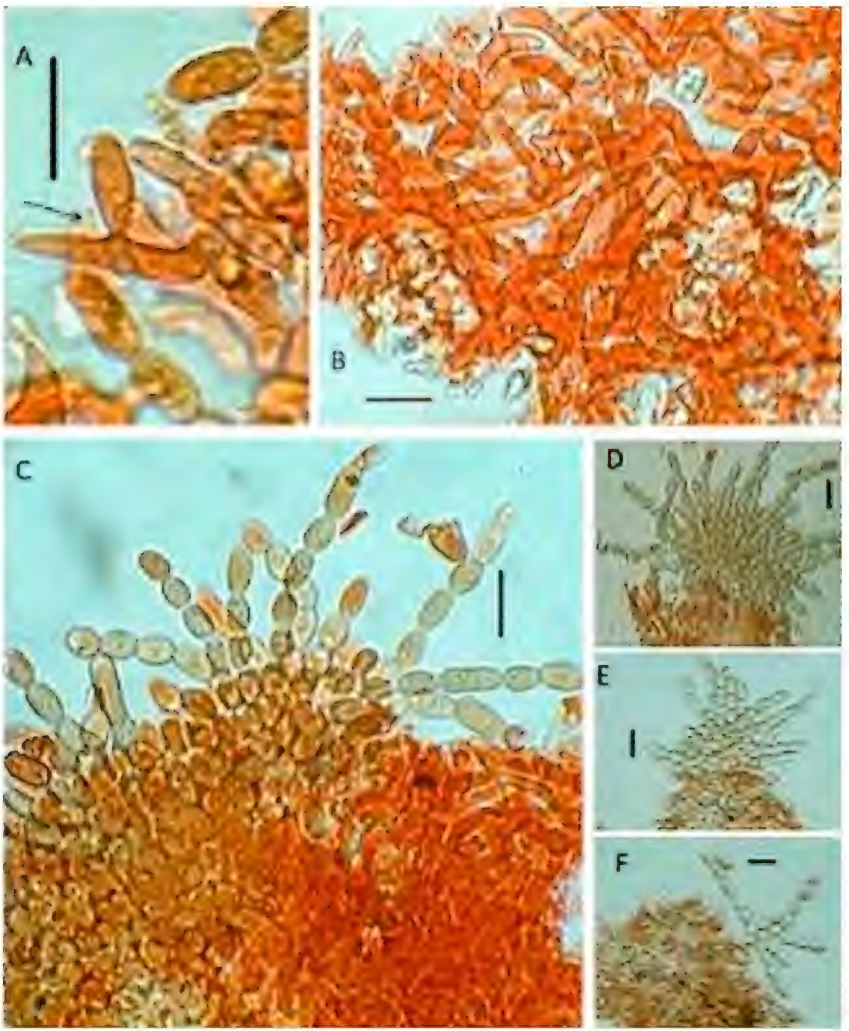

Fig. 3. *Brykendrickia catenata* (holotype, PAN 32735).
A. Conidiogenous cell arising from hyphae (arrow showing point of attachment);
B. Intermixed mycelium; C–F. Conidia attached to conidiogenous cell and mycelium.
Scale bars = 10 μm.

Type—India. Himachal Pradesh: Mandi district, 31°42′N 76°56′E, 800 m, from dead and fallen culms of a *Bambusa* sp., 22 July 2015, R.K. Verma (PAN 32735).

Etymology—Latin, *catenata*, referring to the catenate conidia.

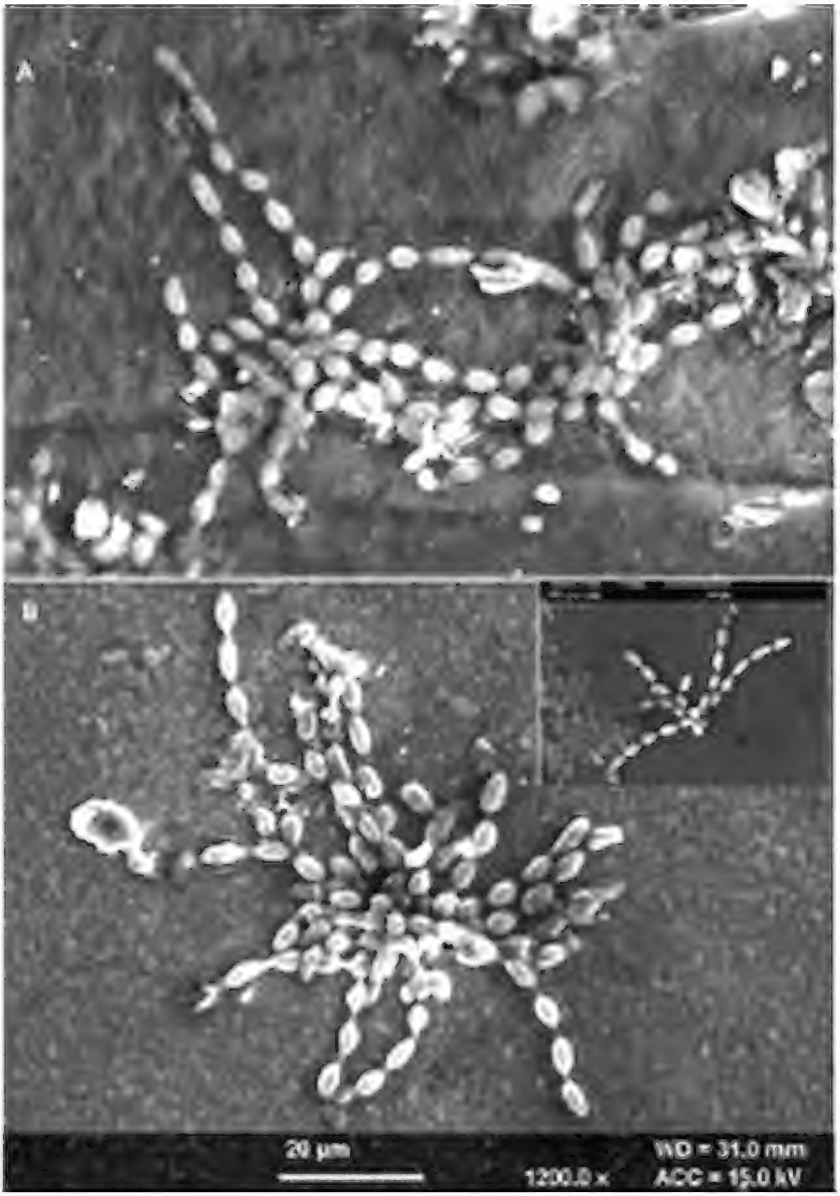

Fig. 4. *Brykendrickia catenata* (holotype, PAN 32735).
Conidia (SEM).

Conidiomata on natural substratum sporodochial, rudimentary pustulate, irregular, blackish with smooth to slightly wavy margins, ≤ 1.8 mm diam. Mycelium mostly superficial, composed of hyaline to subhyaline, septate, rarely branched, smooth hyphae, 2.6–3.2 µm. Conidiophores undifferentiated, reduced to conidiogenous cells. Conidiogenous cells polyblastic, discrete or integrated, rarely monoblastic, cylindrical to clavate, hyaline, 7.8–10.6 × 3.2–4.5 µm. Conidial secession schizolytic. Conidia loosely cheiroid, blastocatenate, branched, sub-hyaline to light grey in colour, 27–74.2 µm long, composed of branches with 5–13(–20), doliiform, oblong, botuliform, globose or subglobose, symmetrical, hyaline, subhyaline to light grey cells, 4–8.7 × 3.2–4.8 µm.

Discussion

Conidial shape and pigmentation in *Brykendrickia* are morphologically reminiscent of several genera, including *Arbusculina* Marvanová & Descals, *Brachyconidiella* R.F. Castañeda & W.B. Kendr., *Brachyconidiellopsis* Decock & al., *Cladoconidium* Bandoni & Tubaki, *Matsushimaea* Subram., *Miricatena* Punith. & Spooner, *Speiropsis* Tubaki, and *Volucrispora* Haskins. *Brykendrickia* differs from *Arbusculina*, *Cladoconidium*, and *Volucrispora* in having a markedly different (terrestrial) ecology contrasting with the truly

Table 1. Comparison of *Brykendrickia* with similar genera

Genus	Conidiomata	Conidiogenesis / conidia	Reference
Brykendrickia	Pustulate to sporodochial rudimentary	Polyblastic (rarely monoblastic)/ loosely cheiroid, blastocatenate, branched, branches with doliiform to oblong, botuliform, globose or subglobose cheiroid, sub-hyaline to light grey cells	Present study
Miricatena	None	Polyblastic/ hyaline, erect, solitary, solitary, complex, composed of almost symmetrical primary & secondary (rarely tertiary) chains	Punithalingam & Spooner 2011
Brachyconidiellopsis	Sporodochial or synnematal	Mono- to polyblastic/ cheiroid, penicilliform, repeatedly branched, branches moniliform, dry, remaining entire at maturity	Decock & al. 2004
Brachyconidiella	Sporodochial or synnematal	Monoblastic/ cheiroid, greyish brown to grayish black, repeatedly branched	Castañeda-Ruiz & Kendrick 1990b

aquatic habitat of the other three "Ingoldian" hyphomycetes (Seifert & al. 2011). In *Speiropsis,* conidiophores are macronematous and multiseptate, conidiogenous cells are polyblastic, and conidia are connected by a narrow cellular isthmus (Seifert & al. 2011). *Matsushimaea* lacks conidiomata, and the conidiogenous cells are monoblastic (Seifert & al. 2011). *Miricatena* (Table 1) lacks sporodochial conidiomata, and the primary conidial chains arise from the conidiogenous cells of the (semi-)macronematous 1–7-septate conidiophores, which further produce secondary (rarely tertiary) hyaline conidial chains (Punithalingam & Spooner 2011). *Brykendrickia* differs from *Brachyconidiella* and *Brachyconidiellopsis* in conidial development and conidiomata (Castañeda-Ruiz & Kendrick 1990b, Decock & al. 2004), which is postulate to rudimentary sporodochial in *Brykendrickia* versus sporodochial or synnematous with differentiated conidiophores in *Brachyconidiella* and *Brachyconidiellopsis* (Table 1).

Acknowledgments

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Distobactrodesmium gen. nov. to accommodate *Bactrodesmium rahmii* and notes on *Bactrodesmium*

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Abstract—A new genus *Distobactrodesmium* is proposed to accommodate *Bactrodesmium rahmii*, characterized by sporodochial conidiomata that produce distoseptate, brown to dark brown phragmoconidia through monoblastic conidiogenous cells. Notes and illustrations on *Bactrodesmium* species are provided.

Key words—asexual fungi, hyphomycetes, taxonomy

Introduction

Bactrodesmium Cooke is typified by *B. abruptum* (Berk. & Broome) E.W. Mason & S. Hughes, as designated by Hughes (1958). Réblová & al. (2020) provided an emended description and revision of *Bactrodesmium*, supported by phylogenetic analysis of the combined ITS, SSU, LSU, rpb2, and tef1-α sequences. The genus is distinguished by sporodochial, punctiform, pulvinate, scattered, brown to black conidiomata composed of (semi-)

macronematous, mononematous, cylindrical (sometimes moniliform), fasciculate or compact aggregated, brown conidiophores. The conidiogenous cells are monoblastic, rarely terminal, determinate, sometimes elongating sympodially, and subhyaline to hyaline. Conidial secession is rhexolytic, and conidia are solitary, acrogenous, variously shaped (globose, subglobose, clavate, pyriform, ellipsoidal, obovoid, fusiform or cylindrical), transversely euseptate (sometimes with a longitudinal or oblique septum), smooth or verruculose, and olivaceous brown or black (Réblová & al. 2020). Réblová & al. (2020) excluded *B. gabretae* Koukol & Kolářová and *B. rahmii* from the genus due to the presence of distoseptate conidia. They accommodated *B. gabretae* in a new genus as *Aphanodesmium gabretae* (Koukol & Kolářová) Réblová & Hern.-Restr., but Réblová & al. (2020) did not propose any taxonomic change for *B. rahmii*, despite its distance from the *Bactrodesmium* generic concept. Therefore, we propose the new genus *Distobactrodesmium* to accommodate this atypical *Bactrodesmium* species.

Taxonomy

Distobactrodesmium Z.F. Niu, K. Zhang & R.F. Castañeda, **gen. nov.**

IF 557439

Differs from *Bactrodesmium* by its distoseptate phragmoconidia.

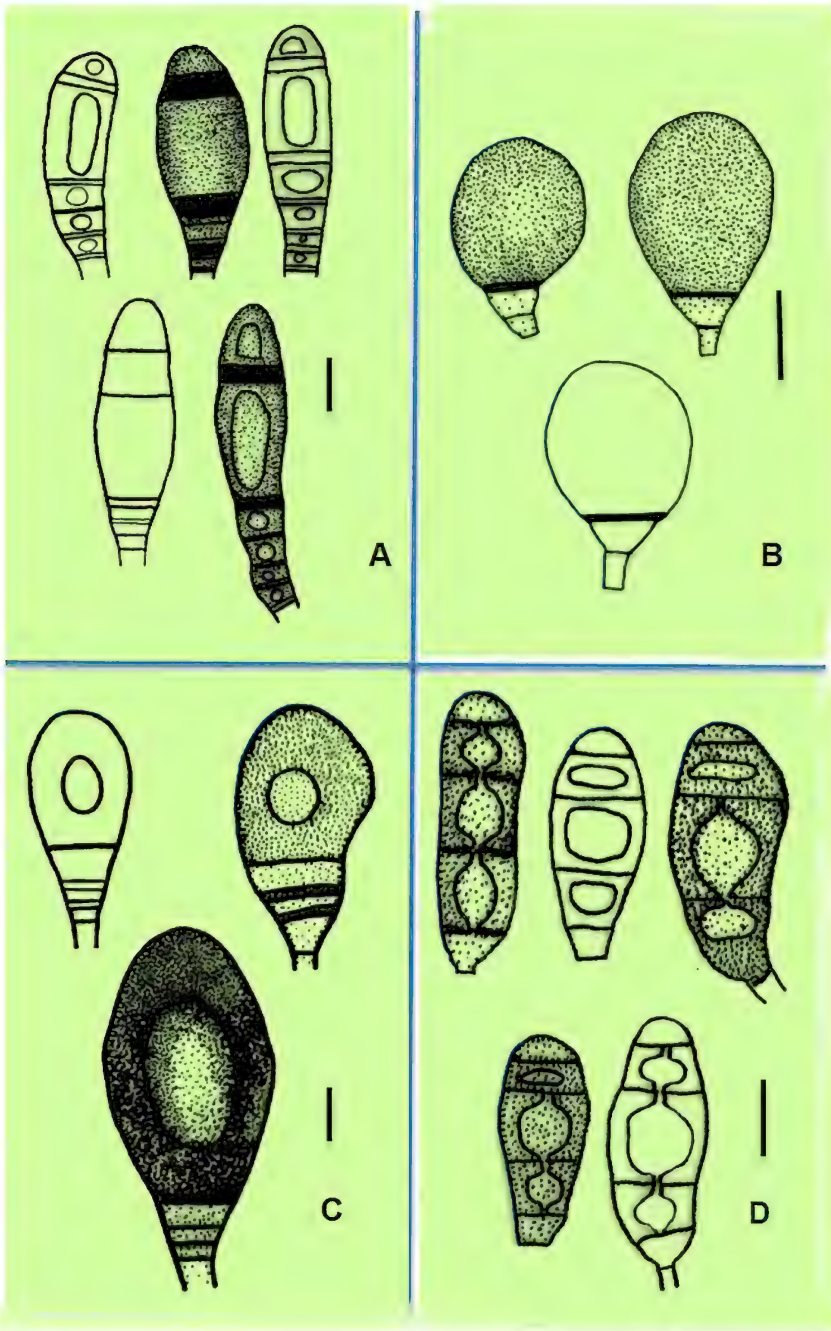
Type species: *Bactrodesmium rahmii* M.B. Ellis [≡ *Distobactrodesmium rahmii* (M.B. Ellis) Z.F. Niu & al.]

Etymology: Latin, *Disto-*, referring to the distoseptate conidia, and *-bactrodesmium*, referring to the genus *Bactrodesmium*.

Conidiomata on natural substrates sporodochial, scattered, pulvinate or irregular, brown to reddish-brown or black. Mycelium superficial and immersed. Stromata rudimentary, textura angularis or globose sometimes present. Conidiophores macronematous, mononematous, unbranched or with short lateral branches, cylindrical, erect, septate, smooth-walled, hyaline or subhyaline. Conidiogenous cells monoblastic, integrated or discrete, cylindrical or slightly clavate (sometimes inflated near the conidiogenous loci), determinate (rarely indeterminate with sympodial extensions), hyaline or subhyaline. Conidial secession rhexolytic. Conidia solitary, acrogenous (sometimes acropleurogenous), obovoid to clavate, distoseptate, sometimes with thin oblique or longitudinal septa, smooth,

Continued on p. 150

Fig. 1. *Bactrodesmium* conidia (re-drawn from the literature). A. *B. abruptum* (Ellis 1959); B. *B. aquaticum* (Borse & al. 2019); C. *B. atrum* (Ellis 1959); *B. betulicola* (Ellis 1959). Scale bars = 10 μm.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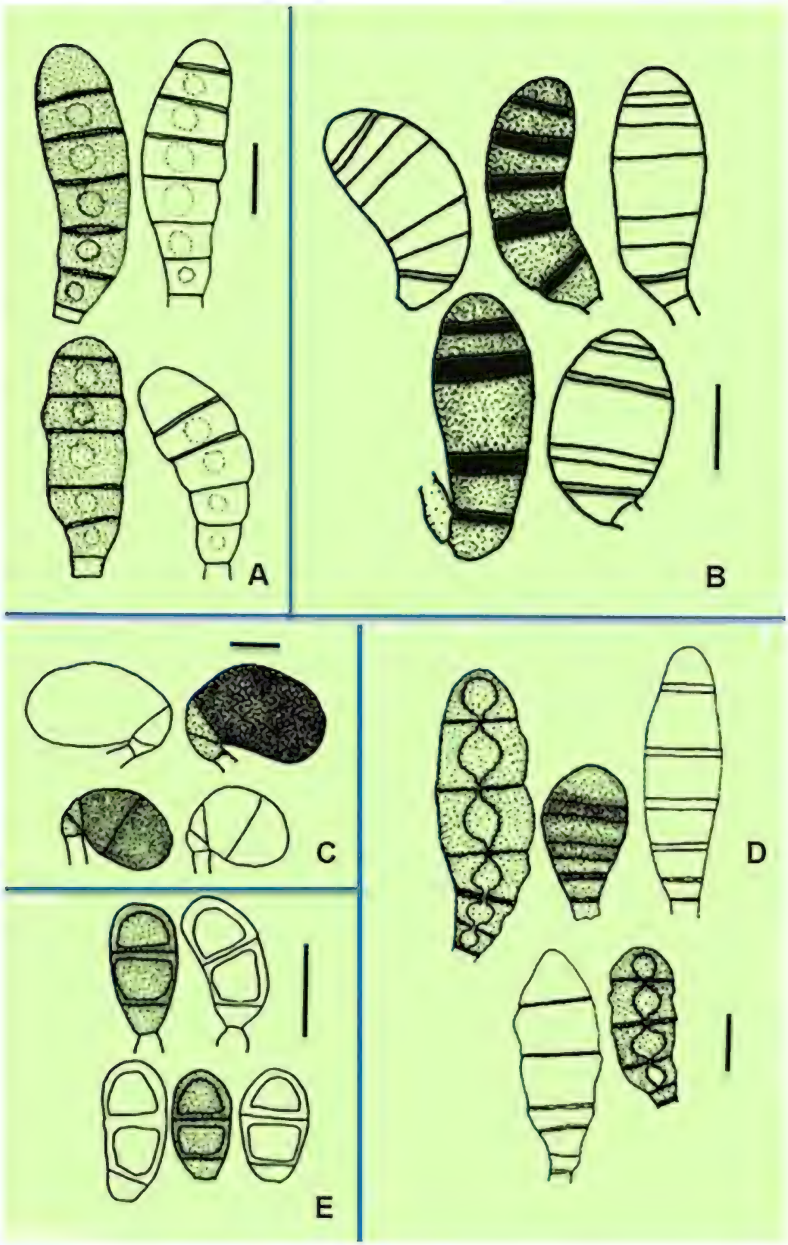

Fig. 2. *Bactrodesmium* conidia (re-drawn from the literature). A. *B. biformatum* (Hughes 1983); B. *B. cedricola* (Ellis 1959); C. *B. curvatum* (Kirk 1985); D. *B. diversum* (Hernández-Restrepo & al. 2013); E. *B. esheri* (Kirk 1983). Scale bars = 10 µm.

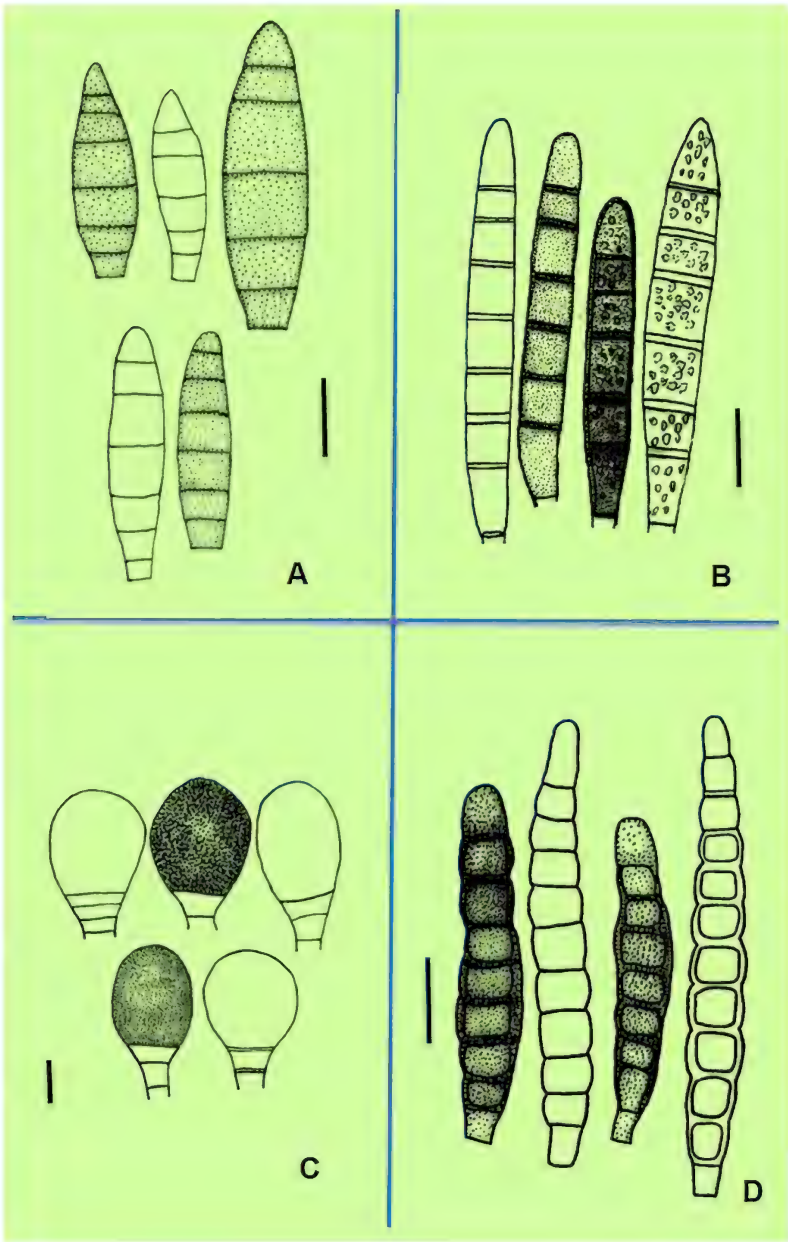

FIG. 3. *Bactrodesmium* conidia (re-drawn from the literature). A. *B. ellipsoideum* (Rao 1983); B. *B. fruticosum* (Matsushima 1993); C. *B. globosum* (Holubová-Jechová 1972); D. *B. guamense* (Matsushima 1981). Scale bars = 10 μm.

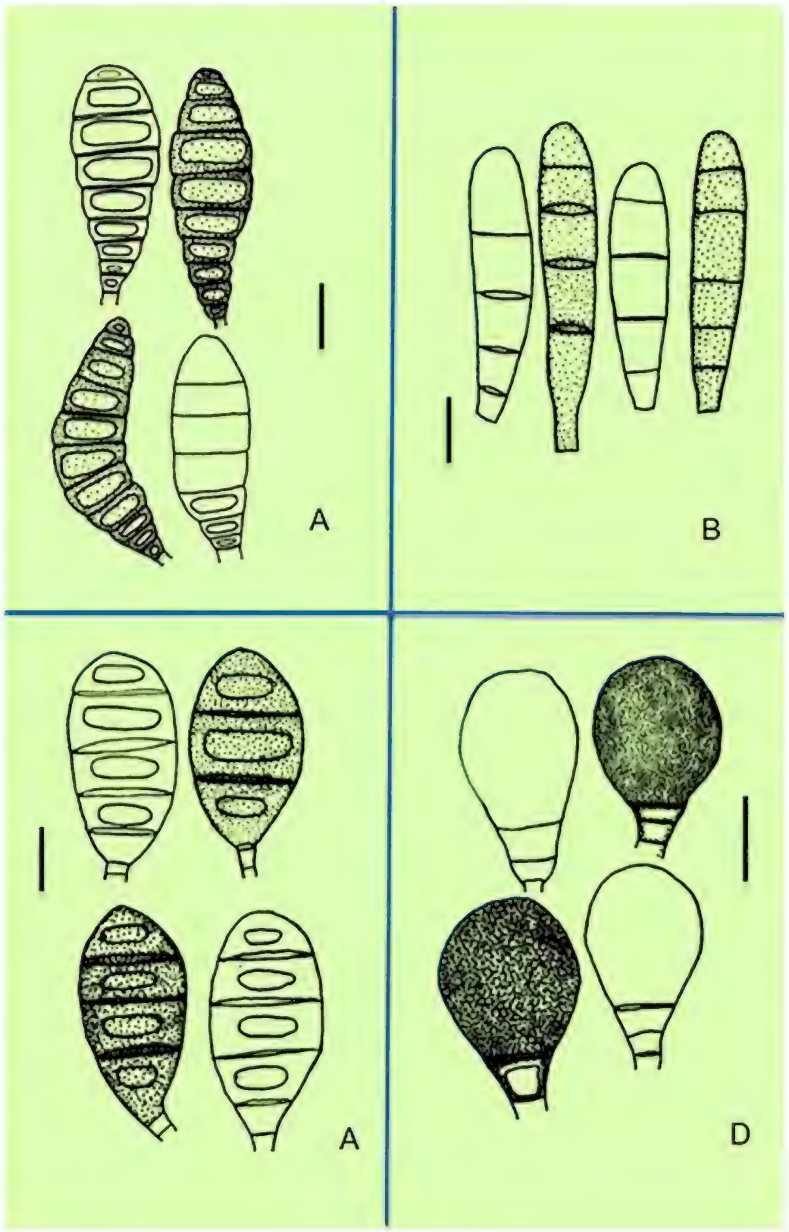

Fig. 4. *Bactrodesmium* conidia (re-drawn from the literature). A. *B. hebridense* (Kirk 1986); B. *B. indicum* (Rao 1983); C. *B. leptopus* (Saccardo 1881); D. *B. linderi* (Palm & Stewart 1982). Scale bars = 10 µm.

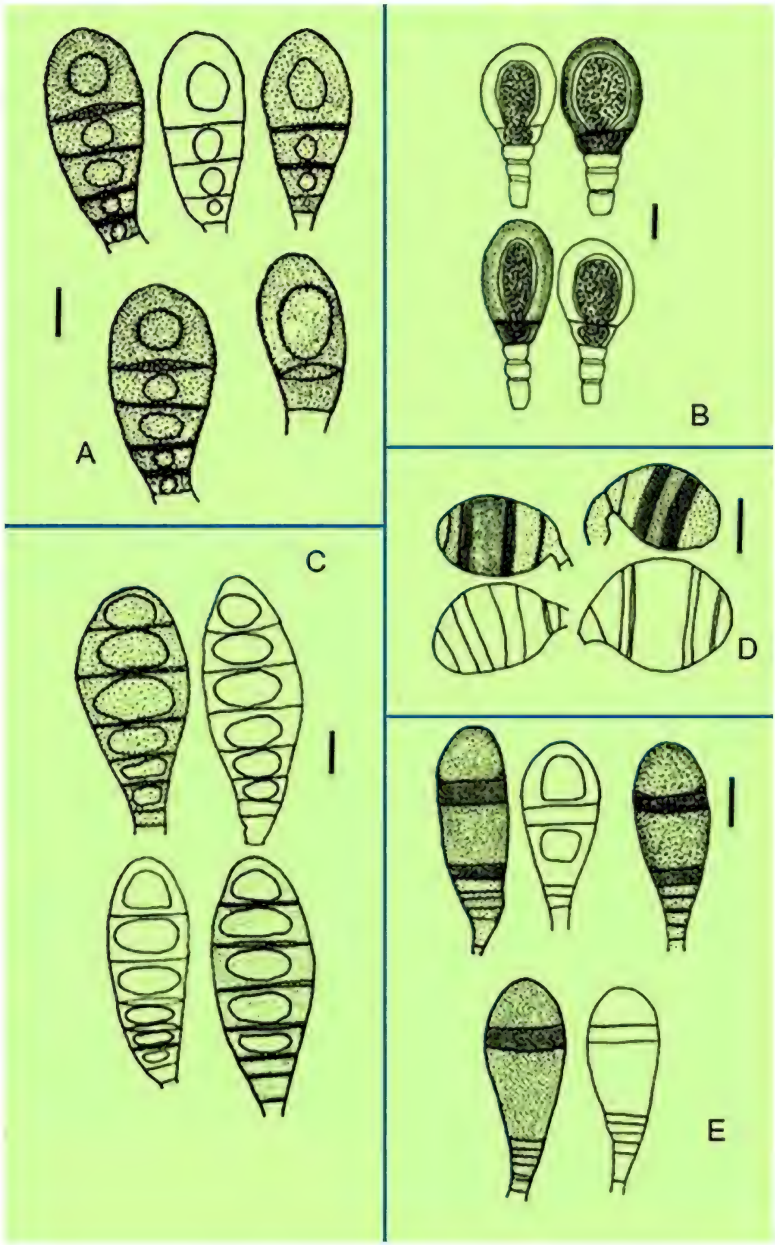

Fig. 5. *Bactrodesmium* conidia (re-drawn from the literature). A. *B. moenitum* (Palm & Stewart 1982); B. *B. mucosum* (Matsushima & Matsushima 1995); C. *B. nothofagi* (Cooper 2005); D. *B. obliquum* (Sutton 1967); E. *B. obovatum* (Ellis 1959). Scale bars = 10 μm.

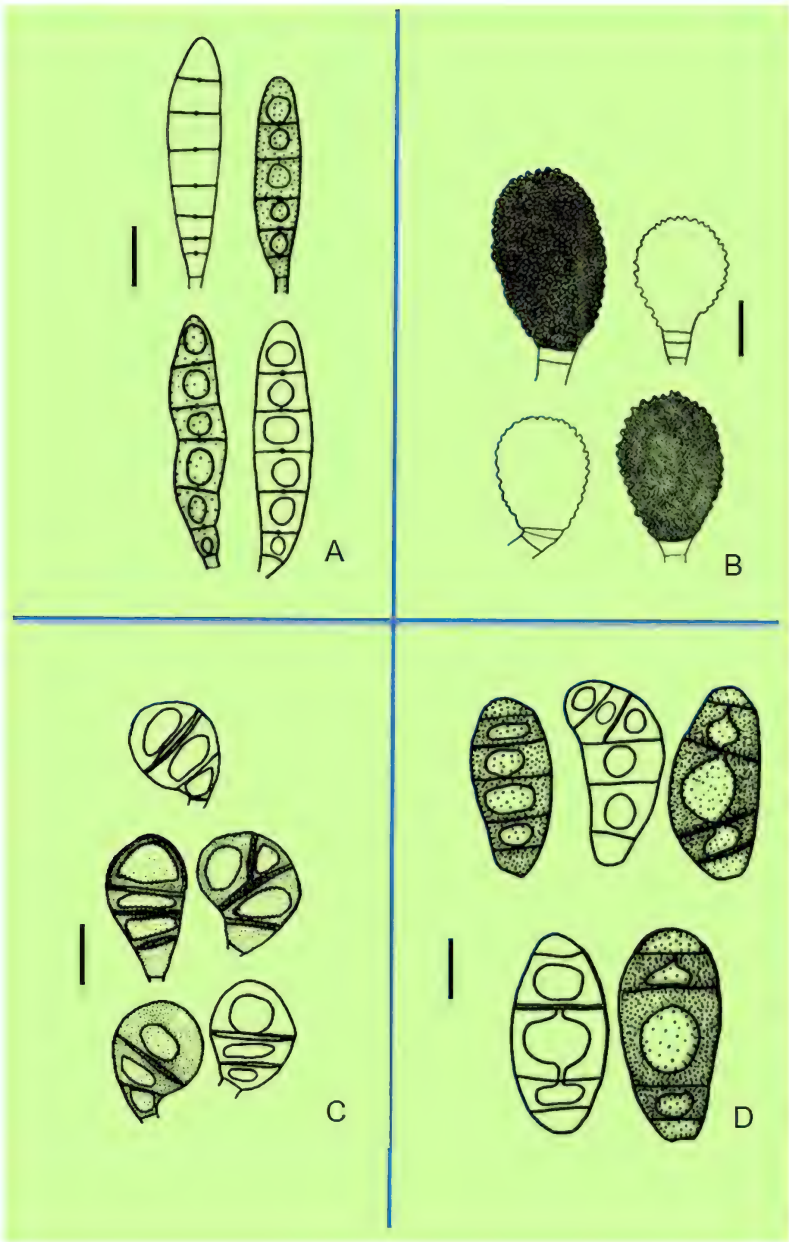

Fig. 6. *Bactrodesmium* conidia (re-drawn from the literature). A. *B. pallidum* (Ellis 1959); B. *B. palmicola* (Mercado Sierra & al. 1995); C. *B. peruvianum* (Sutton 1977); D. *B. pithoideum* (Sutton 1975). Scale bars = 10 µm.

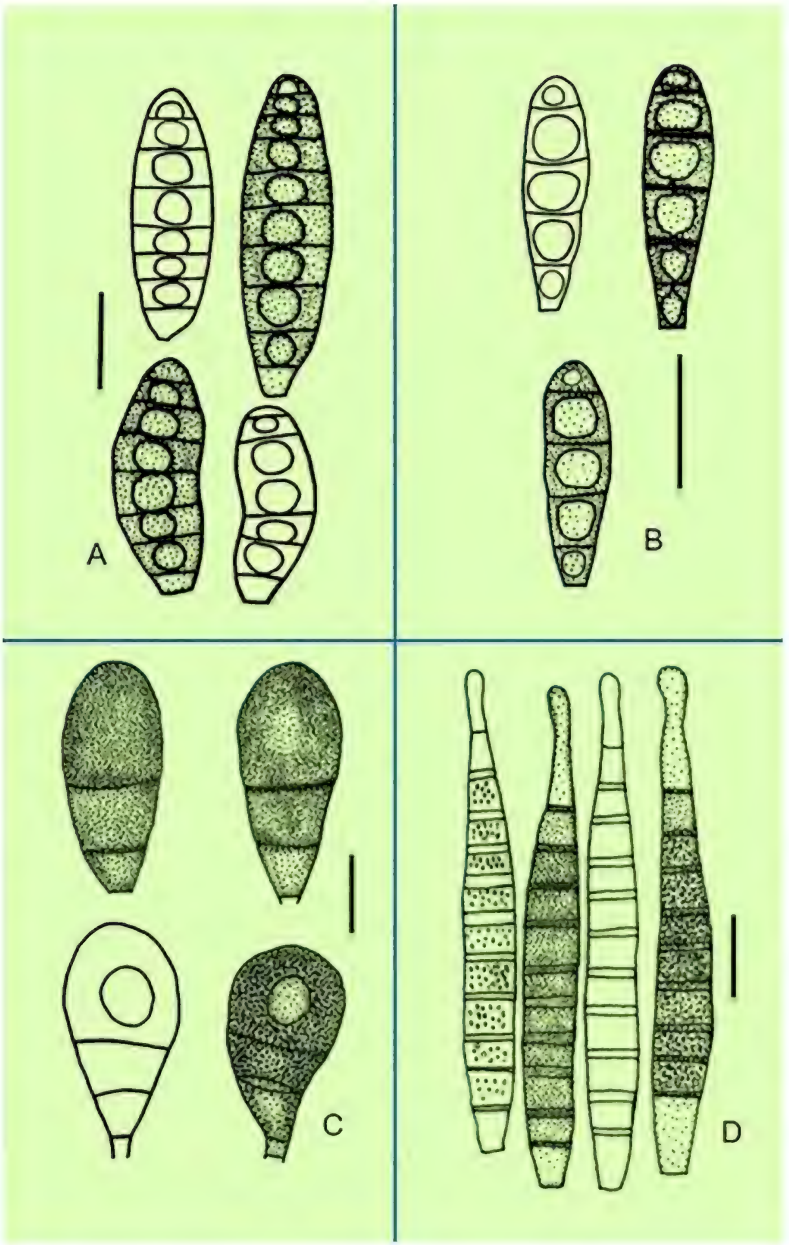

FIG. 7. *Bactrodesmium* conidia (re-drawn from the literature). A. *B. pluriseptatum* (Révay 1993); B. *B. pusillum* (Markovskaja 2006); C. *B. pyriforme* (Holubová-Jechová 1972); D. *B. ramosius* (Matsushima 1993). Scale bars = 10 µm.

brown to dark brown, with one or two hyaline or subhyaline cells toward the fimbriate base.

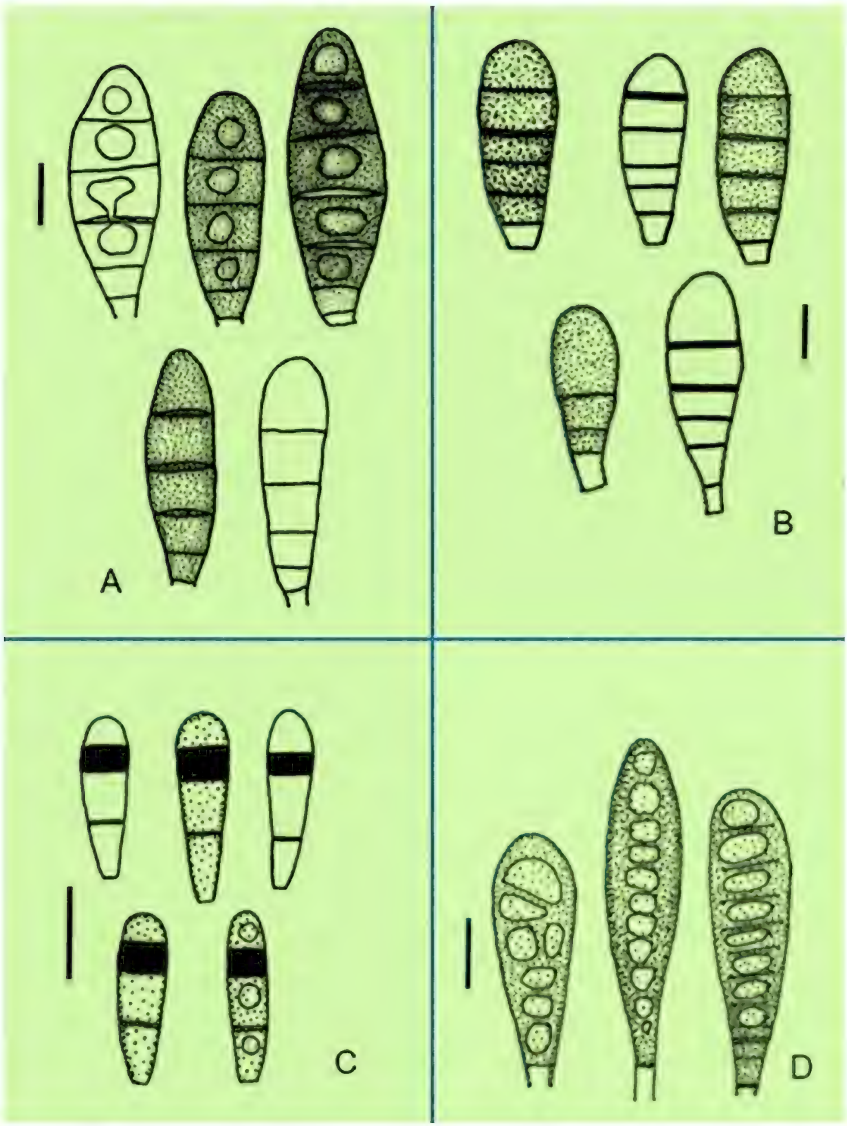

FIG. 8. *Bactrodesmium* and *Distobactrodesmium* conidia (re-drawn from the literature). A. *B. spilomeum* (Hughes & White 1983b); B. *B. traversoanum* (Ellis 1959); C. *B. xerophilum* (Borowska 1975); D. *D. rahmii* (Ellis 1976). Scale bars = 10 µm.

Distobactrodesmium rahmii (M.B. Ellis) Z.F. Niu, K. Zhang & R.F. Castañeda, **comb. nov.** FIG. 8D

IF 557440

≡ *Bactrodesmium rahmii* M.B. Ellis, More Demat. Hyphomyc.: 68 (1976).

Distobactrodesmium rahmii differs from all accepted *Bactrodesmium* species (FIGS 1–10, TABLE 1) by its distoseptate conidia, as noted by Hughes & White (1983d) and Réblová & al. (2020). The conidia have cells with a much reduced lumen and a particular septation sequence (Hughes & White 1983d). This species has been recorded as an endophytic fungus associated with *Ziziphus* sp. (*Rhamnaceae*) in Oman (El-Nagerabi & al. (2013) and has also been found on decaying leaf litter of *Hevea brasiliensis* (Willd. ex A. Juss) Müll. Arg. (*Euphorbiaceae*) in Thailand (Seephueak & al. 2010) and on bark and dead branches of *Picea* sp. (*Pinaceae*) in Canada and Switzerland (Ellis 1976, Hughes & White 1983d).

Discussion

Conidial ontogeny and conidiogenous events have been considered fundamental criteria for asexual fungal taxonomy and generic delimitation (Kendrick 2017, Seifert & al. 2011). Following their multigene DNA analyses, Réblová & al. (2020) accommodated four atypical *Bactrodesmium* species within three new genera: *Aphanodesmium* (for *A. gabretae*) and *Kaseifertia* Réblová & al. (for *K. cubense* (R.F. Castañeda & G.R.W. Arnold) Réblová & al.), both genera characterized by rhexolytic conidial secession, and *Gamsomyces* Hern.-Restr. & Réblová (for *G. longisporus* (M.B. Ellis) Hern.-Restr. & Réblová (type) and *G. stilboideus* (R.F. Castañeda & G.R.W. Arnold) Hern.-Restr. & Réblová), characterized by schizolytic conidial secession. Several *Bactrodesmium* species (FIGS 1–10, TABLE 1) have been described and illustrated with a truncate conidial base produced after schizolytic conidial secession: e.g., *B. betulicola* M.B. Ellis, *B. moenitum* (J.L. Crane & Shearer) M.E. Palm & E.L. Stewart, *B. nothofagi* J.A. Cooper, *B. pithoideum* (Dearn. & House) B. Sutton, *B. pluriseptatum* Révay, and *B. pusillum* Markovsk. (Ellis 1959, Sutton 1975, Palm & Stewart 1982, Révay 1993, Cooper 2005, Markovskaja 2006). Despite their apparent schizolytic secession, these species still remain in *Bactrodesmium* (Réblová & al. 2020). Additional morphological and molecular studies will probably result in the segregation of other species into new genera

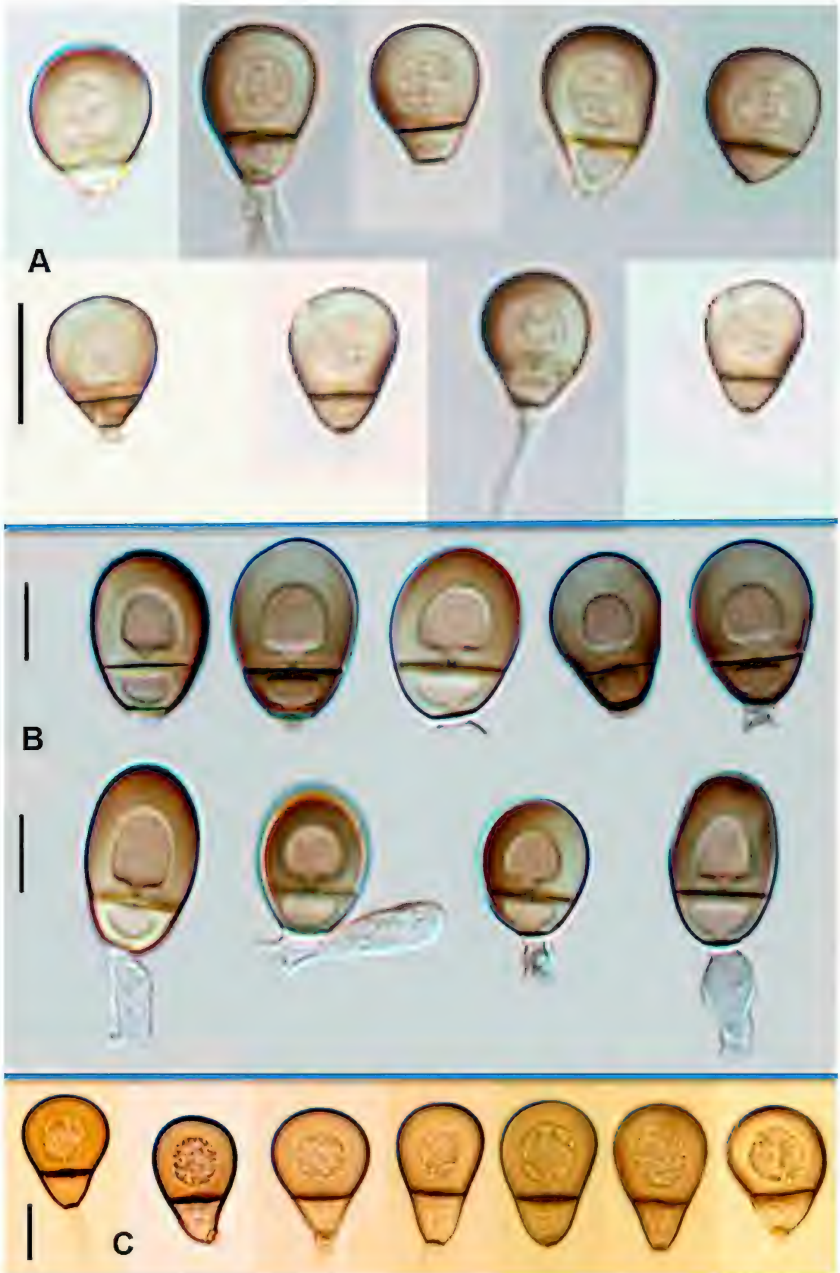

Fig. 9. *Bactrodesmium* conidia. A. *B. novageronense* (Espinoza & al. 2020). B. *B. pulcherrimum.* (Espinoza & al. 2020). C. *B. simile* (Arias & al. 2016). Scale bars = 10 µm.

Fig. 10. *Bactrodesmium* conidia.
A. *B. chinense* (Shi & al. 2020). B. *B. lushanense* (Shi & al. 2020).

Table 1. Comparative conidial morphology of accepted *Bactrodesmium* species and *Distobactrodesmium rahmii*.

Species	Shape	Septa	Conidial size (μm)	Fig.	Reference
B. abruptum	Clavate to oblong-clavate	3–7	32–70 × 12–17	1A	Ellis 1959
B. aquaticum	Broadly pyriform	2	15–26 × 10–18	1B	Borse & al. 2019
B. atrum	Obovoid	3–5	43–72 × 22–38	1C	Ellis 1959
B. betulicola	Ellipsoidal or cylindrical	4	26–40 × 9–15	1D	Ellis 1959
B. biformatum	Ellipsoidal to clavate	(3–)5–7 (–9)	23–40 × 7–9	2A	Hughes 1983
B. cedricola	Ellipsoidal, cylindrical or clavate	1–6	20–35 × 9–18	2B	Ellis 1959
B. chinense	Ellipsoidal to broadly fusiform or navicular	(9–)10 (–11)	54–63.5 × 23.5–26.5	10A	Shi & al. 2020
B. curvatum	Subglobose to broadly pyriform	3	24–32 × 14–20	2C	Kirk 1985
B. diversum	Ellipsoidal or clavate, sometimes obovoid, pyriform or sigmoid	2–5	18–64 × 10–18	2D	Hernández-Restrepo & al. 2013
B. ellipsoideum	Broad ellipsoidal to fusiform or navicular	5–6	30–42 × 9–12	3A	Rao 1983
B. esheri	Ellipsoidal to obovoid	2	10.5–15 × 5.5–7.5	2E	Kirk 1983
*B. fruticosum**	Cylindrical	(2–)4–6 (–8)	30–55 × 5–6.5	3B	Matsushima 1993
B. globosum	Obovoid or broadly clavate	2–3	30–47.5 × 20–24	3C	Holubová-Jechová 1972
*B. guamense**	Cylindrical-fusiform or cylindrical-clavate	3–13	20–62.5 × 5.5–8	3D	Matsushima 1981
B. hebridense	Ellipsoidal	8–11	36–54 × 11–15	4A	Kirk 1986
B. indicum	Clavate to cylindrical	4–5	35–52 × 7–11	4B	Rao 1983

Species	Shape	Septa	Conidial size (µm)	Fig.	Reference
B. leptopus	Clavate, ellipsoidal or broadly obovoid	3–5	21–44 × 11.5–15.5	4C	Saccardo 1881
B. linderi	Pyriform to broadly pyriform to globose	(0–)1–2 (–3)	15–28 × 11–18	4D	Palm & Stewart 1982
B. lushanense	Obovoid, clavate or ellipsoidal	(3–)5(–6)	25.5–41.5 × 14–18.5	10B	Shi & al. 2020
B. moenitum	Obovoid to pyriform	3–4	28–48 × 9–31	5A	Palm & Stewart 1982
*B. mucosum**	Broadly clavate	3–5	35–60 × 20–30	5B	Matsushima & Matsushima 1995
B. nothofagi	Obovoid to pyriform	5–8	47–55 × 18–25	5C	Cooper 2005
B. novageronense	Obovoid to subglobose	1	8–13 × 7–10	9A	Castañeda-Ruiz 1985
B. obliquum	Ovoid	4-transverse, 0–3 oblique	23–33.5 × 16–21.5	5D	Espinoza & al. 2020 Sutton 1967
*B. obovatum***	Clavate	4–5	28–58 × 15–23	5E	Ellis 1959, Ellis 1963, Hughes & White 1983a
B. pallidum	Cylindrical, ellipsoidal or clavate	5–6	35–55 × 9–12	6A	Ellis 1959
B. palmicola	Obovoid, clavate or ellipsoidal	3–4	22–44 × 15–22	6B	Mercado Sierra & al. 1995
B. peruvianum	Pyriform to obovoid	2–3-transverse 1-oblique	14–20 × 11.5–13.5	6C	Sutton 1977
B. pithoideum	Obovoid to sub-reniform	4	22.5–29.5 × 11.5–14.5	6D	Sutton 1975
B. pluriseptatum	Ellipsoidal or cylindrical	6–9	30–44 × 11–14	7A	Révay 1993
B. pulcherrimum	Broadly obovoid to subnapiform	1	18–24 × 13–19	9B	Espinoza & al. 2020
B. pusillum	Elongated ellipsoidal to clavate	(4–)5 (–6)	18–25 × 6.5–7.5	7B	Markovskaja 2006
B. pyriforme	Obovoid to pyriform	2	26–30 × 12.5–16	7C	Holubová-Jechová 1972
B. ramosius	Narrow fusiform	8–12	40–64 × 5–7	7D	Matsushima 1993

Species	Shape	Septa	Conidial size (μm)	Fig.	Reference
B. simile	Broadly pyriform to obovoid	1	19–24 × 12–16	9C	Arias & al. 2016
B. spilomeum	Obovoid or clavate to narrowly ellipsoidal	(3–)4–5 (–6)	25–49 × 9–16	8A	Hughes & White 1983b
B. traversoanum	Ellipsoidal or clavate	3–6	20–37 × 8–12	8B	Ellis 1959 Hughes & White 1983c
B. xerophilum	Cylindrical, ellipsoidal or obovoid	2	14–26 × 3.5–7.5	8C	Borowska 1975
D. rahmii	Obovoid to clavate	4–10-distoseptate	32–58 × 13–18	8D	Ellis 1976

* Morphological data from culture; **as "*Bactrodesmium arnaudii*"

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Physalidiella pentagona sp. nov. from Guizhou, China

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Abstract—A new species, *Physalidiella pentagona*, collected on dead twigs of *Lindera communis* in Guizhou Province, China, is described and illustrated. The fungus is mainly characterized by differentiated conidiophores with opposite or verticillate short branches and monoblastic, percurrently extending conidiogenous cells that produce solitary, smooth, quasi-stellate or T-shaped conidia with an approximately pentagonal central cell and two smaller hemispherical lateral cells. A dichotomous key to *Physalidiella* species is provided.

Key words—hyphomycetes, saprophytic fungi, taxonomy

Introduction

Physalidiella Rulamort was originally established by Rulamort (1990) with *Physalidium elegans* Luppi Mosca [≡ *Physalidiella elegans* (Luppi Mosca) Rulamort] as the type species, which was collected from stubble of *Triticum* in Italy. Morelet (1995) added a second species, *P. matsushimae* (R.F. Castañeda & W.B. Kendr.) M. Morelet [≡ *Physalidium matsushimae* R.F. Castañeda & W.B. Kendr.], with a type specimen from Cuba on rotten leaves of *Cupania americana*. Only these two species have been recognized in this genus. *Physalidiella* is characterized by macronematous, mononematous

conidiophores with short branches arranged in verticils, and monoblastic, integrated, terminal, determinate or occasionally percurrently extending conidiogenous cells that produce solitary, acrogenous, smooth conidia which are composed of an obovoid, ellipsoidal, fusiform-ventricose, biconic or approximately pentagonal, mid to dark brown central cell and two smaller, hemispherical, subspherical or obturbinate, hyaline to subhyaline, lateral cells (Ellis 1971, Rulamort 1990, Seifert & al. 2011).

A survey of saprobic microfungi on dead twigs from subtropical forest in Guizhou Province of China has revealed a previously undescribed *Physalidiella* species. The specimen is deposited in the Mycological Herbarium of Zunyi Normal College, Zunyi, China (HMZNC).

Physalidiella pentagona Z.J. Xiao & Xiao X. Li, **sp. nov.** Fig. 1

FN 570000

Differs from *Physalidiella elegans* and *P. matsushimae* by its percurrently extending conidiogenous cells, and its conidia with an approximately pentagonal or turbinate, slightly shorter middle cell.

Type: China, Guizhou Province: Xishui National Nature Reserve, saprobic on dead twigs of *Lindera communis* Hemsl. (*Lauraceae*), 31 Dec. 2018, Xiao X. Li (**Holotype**, HMZNC 0687).

Etymology: *pentagona*, refers to the shape of middle conidial cell.

Colonies on the dead twigs effuse, arachnoid or velvety, brown. Mycelium partly superficial and partly immersed in the substrate, composed of branched, septate, pale brown to brown, cylindrical, smooth-walled hyphae, 2–3 µm wide. Conidiophores macronematous, mononematous, single or in groups of 2–4, with short branches arranged in verticils: stipe straight or flexuous, subulate, smooth, thick-walled, 5–11-septate, 95–245 × 4–9.5 µm, brown to dark brown, usually a swollen node being formed by stipe extension in the upper portion of stipe, 6.5–10.5 µm wide, pale brown towards the apex, slightly swollen at the base, dark brown, 4.5–12 µm wide; short branches arising just below the stipe septa, opposite or verticillate, subulate, 7.5–24 µm long, 2–5 µm wide at the base, 0–4-septate, pale brown to brown. Conidiogenous cells monoblastic, integrated, terminal on stipe and short branches, subulate, doliiform, lageniform or cylindrical, with up to 4 successive percurrent extensions, pale brown, 1–2.5 µm wide at the apex. Conidia solitary, dry, acrogenous, smooth, complex, quasi-stellate or T-shaped, with a central cell approximately pentagonal or turbinate, smooth-walled, mid to dark brown, 5.5–8.5 × 5–7.5 µm, angled

Fig. 1. *Physalidiella pentagona* (holotype, HMZNC 0687).
A. Conidiophores and conidia; B. Stipes and short branches arranged in verticils, apices showing percurrent extensions of conidiogenous cells; C. Colonies arising from twig surface; D. Conidia.

with a slight camber at the apex, narrow truncate base, 1–2.3 μm wide, and with two lateral cells hemispherical, hyaline to subhyaline, smooth-walled, 4–5.5 × 2–4 μm; overall conidial dimensions 5.5–8.5 × 10.5–13 μm.

Comments—Our new species, *P. pentagona,* is distinguished from other *Physalidiella* species by its obviously percurrently extending conidiogenous cells and approximately pentagonal or turbinate middle conidial cell. In addition, the middle conidial cell of *P. pentagona* is slightly shorter than those of *P. elegans* (7–11 μm) and *P. matsushimae* (8–10 μm).

Key to species of *Physalidiella*

1. Conidiogenous cells with 1–4 percurrent extensions, conidial central cell approximately pentagonal, 5.5–8.5 × 5–7.5 μm ..... *P. pentagona*
1. Conidiogenous cells without obviously percurrent extensions 2
2. Conidial central cell obovoid or ellipsoidal, 7–11 × 6–7 μm ..... *P. elegans*
2. Conidial central cell fusiform-ventricose or biconic, 8–10 × 5–6 μm ..... *P. matsushimae*

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Blastophragmia plurisetulosa gen. & sp. nov. from China

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Abstract—A new asexual ascomycete genus and species, *Blastophragmia plurisetulosa,* is described and illustrated from a specimen collected on dead branches of unidentified plants in Hainan Province, China. The fungus is distinguished by macronematous, unbranched, determinate or percurrently extending conidiophores, and solitary, acrogenous, fusiform to ellipsoidal, 3-euseptate, smooth, brown conidia with a single apical setula and 2–4 basal setulae, seceding rhexolytically from monoblastic, integrated, terminal conidiogenous cells. A key to *Blastophragmia* and its morphologically similar genera is provided.

Key words—asexual *Ascomycota*, hyphomycetes, saprobes, taxonomy

Introduction

Hainan Province is located at the southernmost extension of China. It covers approximately 35,400 km^2, and has a unique natural geographic environment, humid tropical monsoon climate with an average annual temperature of 22.5–25.6°C and average annual precipitation of 1500–2500 mm, which is especially favorable for various plant and microbial species.

During our continuing surveys of saprobic hyphomycetes from plant debris in the forest ecosystems of this province, an interesting fungus was collected that showed remarkable differences from all previously described hyphomycetes (Seifert & al. 2011). Thus, it is described here as a new genus and species.

Materials & methods

Samples of dead branches were collected and placed in Ziploc™ plastic bags for transport to the laboratory, where they were processed, and examined as described by Ma & al. (2011). Microphotographs were prepared using a Nikon Eclipse E200 and SmartV550Dc digital camera, with a 100 × (oil immersion) objective at the same background and scale. Adobe Photoshop 7.0 was used for image processing to assemble photographs into plates. The studied specimens are deposited in the Herbarium of Jiangxi Agricultural University, Plant Pathology, Nanchang, China (HJAUP).

Taxonomy

Blastophragmia Jian Ma, L.G. Ma, X.G. Zhang & R.F. Castañeda, **gen. nov.**

IF 557506

Differs from *Endophragmiella* by its setulate conidia; and from *Stratiphoromyces* by its conidiophores that are either determinate or with several enteroblastic percurrent extensions and its uncurved conidia.

Type species: *Blastophragmia plurisetulosa* Jian Ma & al.

Etymology: Latin, *Blasto-*, referring to the blastic conidial ontogeny, + Greek, *-phragmia*, referring to the phragmospores.

Conidiophores macronematous, mononematous, unbranched, septate, brown to dark brown, paler towards the apex, determinate or indeterminate with several enteroblastic percurrent extensions. Conidiogenous cells monoblastic, integrated, terminal, cylindrical. Conidial secession rhexolytic. Conidia solitary, acrogenous, smooth, fusiform to ellipsoidal, euseptate, setulate, usually bearing a basal frill.

Blastophragmia plurisetulosa Jian Ma, L.G. Ma, X.G. Zhang & R.F. Castañeda, **sp. nov.** Fig. 1

IF 557507

Differs from *Endophragmiella* spp. by its setulate conidia; and from *Stratiphoromyces* spp. by its conidiophores either determinate or with several enteroblastic percurrent extensions, and its uncurved, fusiform to ellipsoidal, 3-euseptate conidia with a single apical setula and 2–4 basal setulae.

Type: China, Hainan Province: Diaoluoshan Mountain, 18°4′N 109°53′E, on dead branches of an unidentified broadleaf tree, 15 April 2015, J. Ma (**holotype**, HJAUP M0349).

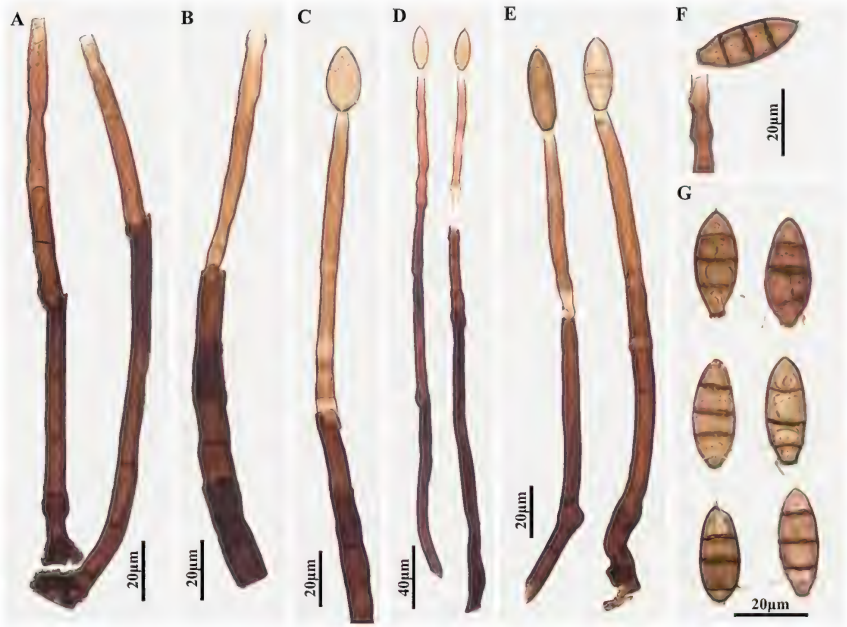

Fig. 1. *Blastophragmia plurisetulosa* (holotype, HJAUP M0349). A, B. Conidiophores showing conidiogenous cells and enteroblastic percurrent extensions, and (in B) conidiophore apex showing an initial conidium. C–E. Conidiophores and conidiogenous cells with immature conidia; F. Conidium seceding rhexolytically from conidiogenous cell; G. Conidia.

Etymology: refers to the multiple setulae, which arise from the conidial base and apex.

Colonies on the natural substrate effuse, brown to dark brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth-walled hyphae. Conidiophores macronematous, mononematous, unbranched, erect, straight or flexuous, cylindrical, smooth, 3–16-septate, brown to dark brown, paler towards the apex, determinate or with 1–3 enteroblastic percurrent extensions, ≤340 µm long, 6.5–13.5 µm wide. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, brown to pale brown, smooth, 20–105 × 5.5–6.5 µm. Conidial secession rhexolytic. Conidia solitary, dry, acrogenous, fusiform to ellipsoidal, smooth, brown, 3-euseptate when mature, 25–32.5 × 10.5–12.5 µm; with a single apical setula and 2–4 basal setulae, thin, 5–10 µm long, straight to curved, hyaline; bearing a distinct 3.5–5 µm wide basal frill.

Discussion

Blastophragmia is distinguished by its monoblastic, integrated, terminal, cylindrical conidiogenous cells on distinct, unbranched, determinate or percurrently extending conidiophores, and solitary, acrogenous, fusiform to ellipsoidal, euseptate, conidia with a single apical setula and 2–4 basal setulae, and rhexolytic conidial secession. *Blastophragmia* appears similar in conidial ontogeny to several existing genera, including *Endophragmiella* B. Sutton (Sutton 1973), *Chaetendophragmia* Matsush. (Matsushima 1971), *Teratosperma* Syd. & P. Syd. (Sydow & Sydow 1909), and *Stratiphoromyces* Goh & K.D. Hyde (Goh & Hyde 1998). However, *Endophragmiella* differs by its asetulate conidia; *Chaetendophragmia* differs by its rostrate conidia with lateral appendages arising from the middle cells; *Teratosperma* differs by its annellidic conidiogenous cells producing conidia with lateral appendages, which arise from the basal cell; and *Stratiphoromyces* differs by its conidiogenous cells with crowded repeating percurrent extensions that lead to the apical portions of conidiophores with multilayers of wall remnants, and its conidia usually aggregating in a mass.

Several other genera, including *Arachnophora* Hennebert (Hennebert 1963), *Acrophragmis* Kiffer & Reisinger (Kiffer & Reisinger 1970), and *Phragmocephala* E.W. Mason & S. Hughes (Mason & Hughes 1951), have the same conidial secession as *Blastophragmia*, but *Arachnophora* differs by its complex conidia with a two-celled central body, from which arise several lateral, radial arms; *Acrophragmis* differs by its conidia with central cell bearing a ring of small knobs; and *Phragmocephala* differs by its asetulate conidia and cupulate or clavate conidiogenous cell.

Key to *Blastophragmia* and morphologically similar genera

1. Conidia with setulae 2
1. Conidia without setulae 3
2. Conidiogenous cells with crowded repeating percurrent extensions ..... *Stratiphoromyces*
2. Conidiogenous cells determinate or with several enteroblastic percurrent extensions ..... *Blastophragmia*
3. Conidia with lateral appendages 4
3. Conidia without lateral appendages 5
4. Conidial lateral appendages arising from the middle cells ..... *Chaetendophragmia*
4. Conidial lateral appendages arising from the basal cell ..... *Teratosperma*

5. Conidia with central cell bearing a ring of small knobs ..... *Acrophragmis*
5. Conidia with central cell not bearing small knobs 6
6. Conidia complex, with a central body bearing several lateral, radial arms ..... *Arachnophora*
6. Conidia simple, without lateral, radial arms 7
7. Conidiogenous loci narrower than rest of conidiogenous cell, conidia with a regular frill around the base ..... *Endophragmiella*
7. Conidiogenous loci as wide as other part of conidiogenous cells, conidia with an irregular frill around the base ..... *Phragmocephala*

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Endophragmiella spp. nov. and new records from southern China

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Abstract—Four new species—*Endophragmiella chinensis*, *E. guangdongensis*, *E. lushanensis*, and *E. obovoidea*—collected on dead branches of unidentified plants in southern China, are described, illustrated, and compared with closely related species. From the same habitat, three other species, *E. cantabrica*, *E. ellisii*, and *E. uniseptata* are recorded from China for the first time.

Key words—asexual *Ascomycota*, hyphomycetes, saprobes, taxonomy

Introduction

Endophragmiella B. Sutton was established (Sutton 1973) for two species, *E. pallescens* B. Sutton (generic type) and *E. canadensis* (Ellis & Everh.) B. Sutton [= *E. subolivacea* (Ellis & Everh.) S. Hughes; see Hughes 1979]. *Endophragmiella* is mainly characterized by solitary, acrogenous, aseptate or euseptate conidia seceding rhexolytically from monoblastic, integrated, terminal, determinate or percurrently elongating conidiogenous cells on simple or branched conidiophores (Sutton 1973, Ellis 1976, Hughes

1979, Holubová-Jechová 1986, Wang 1990, Wu & Zhuang 2005, Seifert & al. 2011). Hughes (1979) clarified the conidiogenesis of *Endophragmiella*, amended the generic concepts, and accepted 33 species. Subsequently, 62 species and one variety have been published in *Endophragmiella* (Index Fungorum 2020). *Endophragmiella cambrensis* M.B. Ellis (Ellis 1976) was excluded from that genus by Hughes (1979) but accepted by Wu & Zhuang (2005). *Endophragmiella dimorphospora* Awao & Udagawa ex P.M. Kirk was treated as a synonym of the prior name *E. biconstituta* (Rambelli) Matsush. by Matsushima (1989). *Endophragmiella fasciata* (R.F. Castañeda) R.F. Castañeda (Castañeda-Ruíz 1988) and *E. quadrilocularis* Matsush. (Matsushima 1993) were transferred to *Repetophragma* Subram. by Castañeda-Ruíz & al. (2006, 2011). *Endophragmiella fuliginosa* (B. Sutton) S. Hughes (Hughes 1979) was treated as *Rhexoacrodictys fuliginosa* (B. Sutton) W.A. Baker & Morgan-Jones by Baker & al. (2002). *Endophragmiella rigidiuscula* R.F. Castañeda (Castañeda-Ruiz 1988) was proposed as the type species of *Distophragmia* R.F. Castañeda & al. (Castañeda-Ruíz & al. 2015). Nine invalid *Endophragmiella* species names have been validated in Senwanna (2019). *Endophragmiella* currently contains 91 species and one variety, of which 46 species have been recorded from China (Matsushima 1980, Tzean & Chen 1989, Lu & al. 2000, Tsui & al. 2001, Zhuang 2001, Wu & Zhuang 2005, Chen & al. 2008, Zhang & al. 2010, Ma & al. 2011, 2012a,b, 2015, Ren & al. 2011, Wu & Zhang 2012, Xia & al. 2016, Li & al. 2017, Jiang & al. 2018).

During an ongoing survey of anamorphic fungi on plant debris in southern China, seven species clearly related to *Endophragmiella* were collected from dead branches. Four are described here as new, and the other three represent new records for the Chinese mycota.

Taxonomy

Endophragmiella chinensis L. Qiu, Jian Ma, R.F. Castañeda & X.G. Zhang, **sp. nov.** Fig. 1

IF 557448

Differs from *Endophragmiella bohaniensis* by its oblong or cylindrical, smaller conidia on branched, shorter, and narrower conidiophores; and from *E. constricta, E. fallacia,* and *E. oblonga* by its smaller, concolorous conidia.

Type: China, Jiangxi Province, Lushan Mountain, on dead branches of an unidentified broadleaf tree, 18 October 2016, J. Ma (**holotype**, HJAUP M0477).

Etymology: refers to China where the fungus was collected.

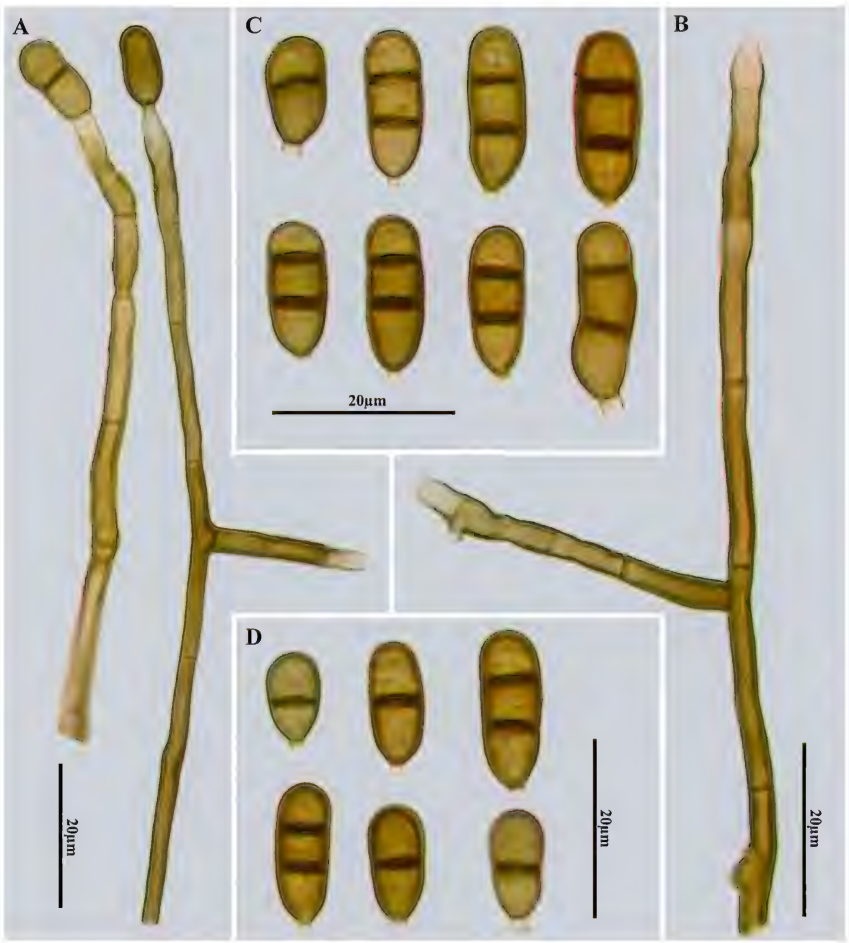

Fig. 1. *Endophragmiella chinensis* (holotype, HJAUP M0477).
A. Conidiophores, conidiogenous cells, and conidia; B. Conidiophore; C, D. Conidia.

Colonies on the natural substrate effuse, brown to dark brown. Mycelium partly immersed, partly superficial, composed of branched, septate, pale brown, smooth-walled hyphae. Conidiophores macronematous, mononematous, single or aggregated at the base, simple or branched, erect, straight or flexuous, septate, smooth, medium brown to brown, paler towards the apex, 83–115 × 2.5–4 μm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, pale brown, attenuated into

narrow and truncate at the apex, with 0–2 percurrent elongations. Conidial secession rhexolytic. Conidia solitary, acrogenous, smooth, thick-walled, (1–)2-euseptate, the septum usually becoming darker and forming a band; when mature oblong or cylindrical, medium brown, (11–)14–21 µm long, (4.5–)6–7.5 µm diam. in the broadest part; apex rounded; base truncate, 1–2 µm diam., with a distinct 1–1.5 µm long basal frill derived from the distal end of the conidiogenous cell.

Comments—Among the *Endophragmiella* taxa with predominantly 2-euseptate conidia, *E. chinensis* is most similar to *E. bohaniensis* N.D. Sharma (Sharma 1985), *E. constricta* M.T. Dunn (Dunn 1982), *E. fallacia* P.M. Kirk (Kirk 1981a), and *E. oblonga* Matsush. ex S. Hughes (Hughes 1979) in conidial shape. However, *E. bohaniensis* differs by its broadly ellipsoidal to oblong, larger conidia (18–33 × 8.5–12.5 µm) on unbranched longer and wider conidiophores (75–300 × 5–6 µm; Sharma 1985); *E. constricta* differs by its brown larger conidia (15–23 × 6.9–10.4 µm) with paler lower cell and constricted middle cell (Dunn 1982); *E. oblonga* and *E. fallacia* differ mainly in their unbranched conidiophores, and larger versicolored conidia (*E. oblonga* 19–28 × 9.5–11.5 µm, Hughes 1979; *E. fallacia* 22–26 × 10–12 µm, Kirk 1981a).

Endophragmiella guangdongensis L. Qiu, Jian Ma, R.F. Castañeda & X.G. Zhang, **sp. nov.** Fig. 2

IF 557449

Differs from *Endophragmiella cesatii* and *E. latispora* by its smaller predominantly 2-euseptate conidia; from *E. lauri* by its versicolored wider conidia; and from *E. curvata* by its wider conidia with the longest central or suprabasal cell.

Type: China, Guangdong Province: Liuxihe National Forest Park, on dead branches of an unidentified broadleaf tree, 17 October 2014, J. Ma (**holotype**, HJAUP M0118).

Etymology: refers to the province in which the fungus was found.

Colonies on the natural substrate effuse, brown to dark brown. Mycelium partly immersed, partly superficial, composed of branched, septate, pale brown, smooth-walled hyphae. Conidiophores macronematous, mononematous, single or aggregated at the base, unbranched, erect, straight or flexuous, septate, smooth, brown to dark brown, up to 530 × 4.5–5.5 µm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, brown, with up to 25 or more percurrent elongations. Conidial secession rhexolytic. Conidia solitary, acrogenous, fusiform or ellipsoidal, smooth, 2(–3)-euseptate, brown with the paler end cells, 20.5–29.5 µm long, 8.5–10.5 µm diam. in the broadest

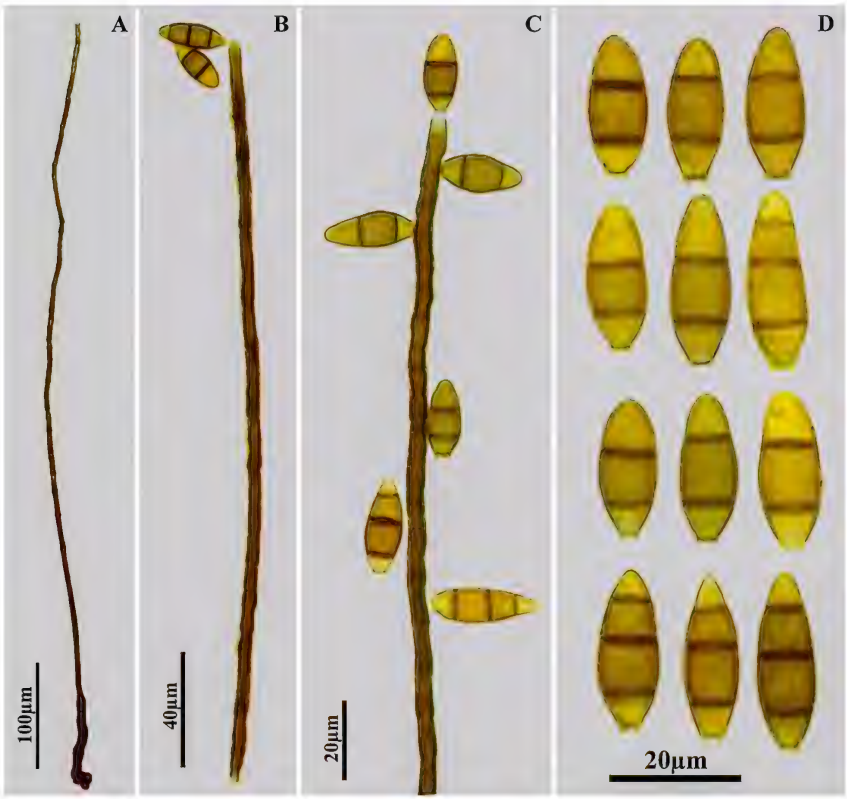

Fig. 2. *Endophragmiella guangdongensis* (holotype, HJAUP M0118).
A. Conidiophore; B, C. Conidiophores, conidiogenous cells, and conidia; D. Conidia.

part; apex rounded or acute; base truncate, 2.5–4 μm diam., with a distinct 0.5–1 μm long basal frill derived from the distal end of the conidiogenous cell.

Comments—In terms of conidial morphology, *E. guangdongensis* is most similar to *E. latispora* W.P. Wu (Wu & Zhuang 2005), *E. lauri* P.M. Kirk & C.M. Kirk (Kirk 1982), and *E. curvata* (Corda) S. Hughes and *E. cesatii* (Mont.) S. Hughes (Hughes 1979), but *E. cesatii* and *E. latispora* differ by their predominantly 3-euseptate, larger conidia (*E. cesatii* 32–40(–45) × 11–12.5 μm, Hughes 1979; *E. latispora* 23–35 × 12–13 μm, Wu & Zhuang 2005); *E. curvata* differs by its narrower (7.2–8.3 μm) conidia with the lowest cell longer than other cells; and *E. lauri* differs by its concolorous, narrower (7–8 μm) conidia (Kirk 1982).

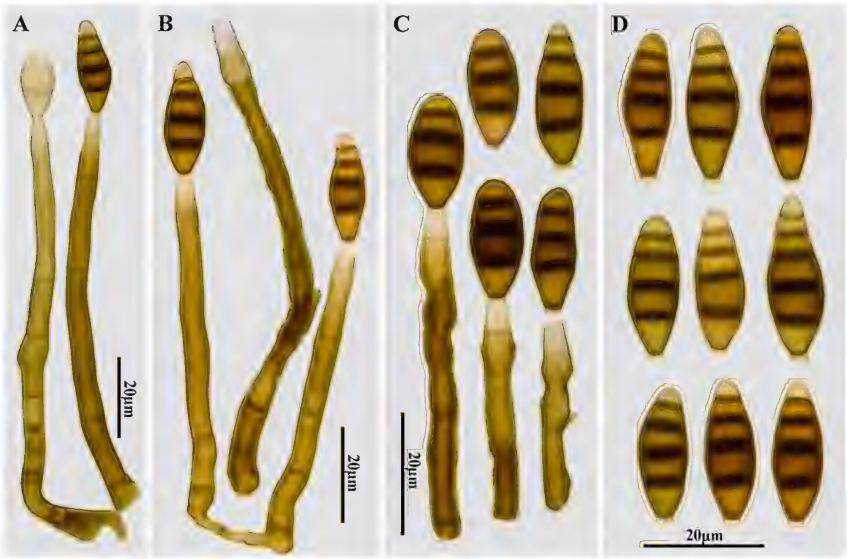

Fig. 3. *Endophragmiella lushanensis* (holotype, HJAUP M0436).
A–C. Conidiophores, conidiogenous cells, and conidia; D. Conidia.

Endophragmiella lushanensis L. Qiu, Jian Ma, R.F. Castañeda & X.G. Zhang, **sp. nov.** Fig. 3

IF 557450

Differs from *Endophragmiella fagicola*, *E. latispora*, *E. socia*, and *E. valdiviana* by its conspicuously smaller predominantly 4-euseptate conidia.

Type: China, Jiangxi Province, Lushan Mountain, on dead branches of an unidentified broadleaf tree, 18 October 2016, J. Ma (**holotype**, HJAUP M0436).

Etymology: refers to the locality in which the fungus was found.

Colonies on the natural substrate effuse, brown to dark brown. Mycelium partly immersed, partly superficial, composed of branched, septate, pale brown, smooth-walled hyphae. Conidiophores macronematous, mononematous, single or aggregated at the base, unbranched, erect, straight or flexuous, septate, smooth, medium brown to dark brown at the lower part, pale brown towards the apex, 54–160 × 4.5–6 μm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, pale brown, attenuated into narrow and truncate apex of 2.5–3 μm wide, determinate, with up to 3 percurrent elongations. Conidial secession rhexolytic. Conidia solitary, acrogenous, ellipsoidal, fusiform or obclavate, smooth, (3–)4(–5)-euseptate, the septum

usually becoming darker and forming a band, medium brown to brown, apical cell pale brown to subhyaline, 20–29 µm long, 7–9 µm diam. in the broadest part; apex rounded; base truncate, 2.5–3 µm diam., with a distinct 0.5–1 µm long basal frill derived from the distal end of the conidiogenous cell.

Comments—Among the known species of *Endophragmiella*, *E. lushanensis* is most similar in conidial shape to *E. fagicola* P.M. Kirk (Kirk 1981b), *E. latispora* (Wu & Zhuang 2005), *E. socia* (M.B. Ellis) S. Hughes, and *E. valdiviana* (Speg.) S. Hughes (Hughes 1979), but *E. fagicola* differs by its obvious larger (70–90 × 11–17 µm) usually 5-euseptate conidia (Kirk 1981b); *E. latispora* differs by its wider (12–13 µm) predominantly 3-euseptate conidia (Wu & Zhuang 2005); *E. socia* and *E. valdiviana* differ by their larger predominantly 7-euseptate conidia (*E. socia* 36–50 × 10.8–14.4 µm; *E. valdiviana* 40–50 × 11–12.5 µm) (Hughes 1979).

Endophragmiella obovoidea L. Qiu, Jian Ma, R.F. Castañeda & X.G. Zhang, **sp. nov.** Fig. 4

IF 557451

Differs from *Endophragmiella occidentalis*, *E. aseptata*, and *E. fatrensis* by its obovoid, smooth, pale brown, smaller conidia.

Type: China, Jiangxi Province: Lushan Mountain, on decaying twigs of an unidentified broadleaf tree, 18 October 2016, J. Ma (**holotype**, HJAUP M0475).

Etymology: refers to the obovoid conidial shape.

Colonies on the natural substratum effuse, brown to dark brown. Mycelium partly immersed, partly superficial, composed of branched, septate, pale brown, smooth-walled hyphae. Conidiophores macronematous, mononematous, single or aggregated at the base, simple, erect, straight or flexuous, septate, smooth, pale brown to brown, paler towards the apex, ≤230 × 3–4 µm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, pale brown, attenuated into narrow and truncate at the apex, with up to 26 (or more) percurrent elongations. Conidial secession rhexolytic. Conidia solitary, acrogenous, smooth, thick-walled, obovoid, sometimes ellipsoidal, aseptate, pale brown, 8–9.5 × 5–6 µm, with a distinct 0.5–1.5 µm long basal frill derived from the distal end of the conidiogenous cell.

Comments—Among the known species of *Endophragmiella* with aseptate conidia, *E. obovoidea* somewhat resembles *E. occidentalis* R.F. Castañeda & al. (Castañeda-Ruíz & al. 1995), *E. aseptata* Hol.-Jech., and *E. fatrensis* Hol.-Jech. (Holubová-Jechová 1986), but *E. occidentalis* differs by its obovate, smooth, rarely verrucose, dark brown, larger conidia (10–12 × 9–11 µm; Castañeda-

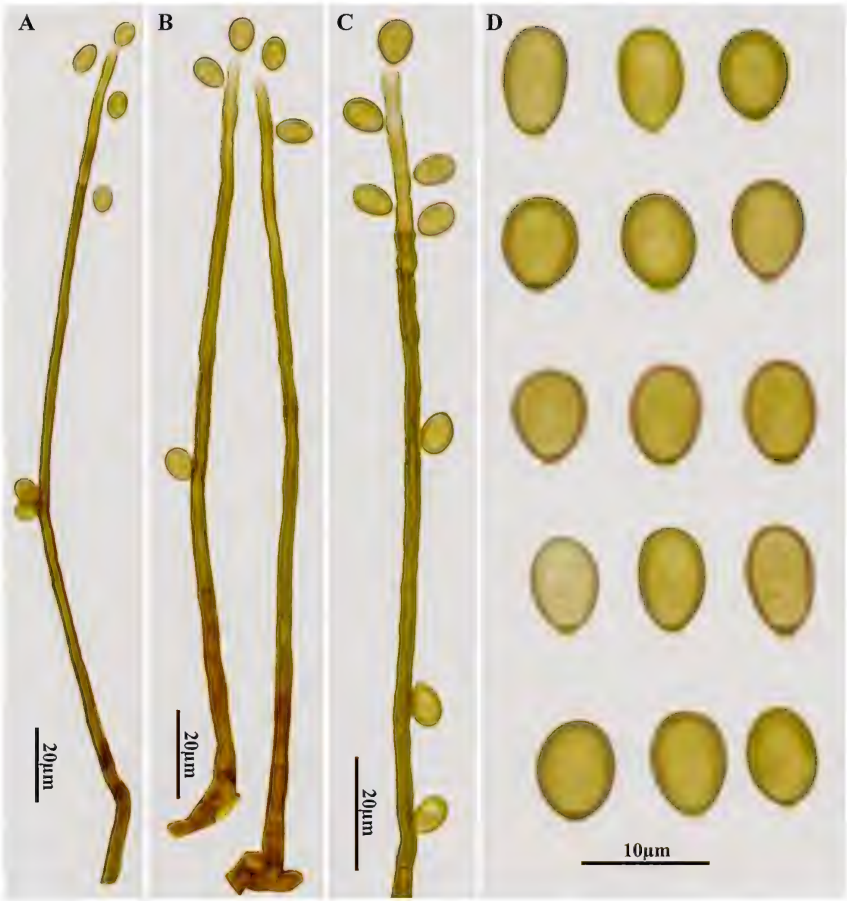

Fig. 4. *Endophragmiella obovoidea* (holotype, HJAUP M0475).
A–C. Conidiophores, conidiogenous cells, and conidia; D. Conidia.

Ruíz & al. 1995); *E. aseptata* differs by its ellipsoidal or ovoid, brown, larger conidia (7–11 × 6–7.5 μm; Holubová-Jechová 1986); and *E. fatrensis* differs by its ellipsoidal to ovoidal, mid to dark smoke-brown, larger conidia (11–15.5 × 7–8.5 μm; Holubová-Jechová 1986].

Endophragmiella cantabrica J. Mena, Hern.-Restr., Gené & Guarro, Mycotaxon 123: 225, 2013. Fig. 5

Conidiophores macronematous, mononematous, single, unbranched, erect, straight or flexuous, 7–13-septate, smooth, brown to dark brown, paler

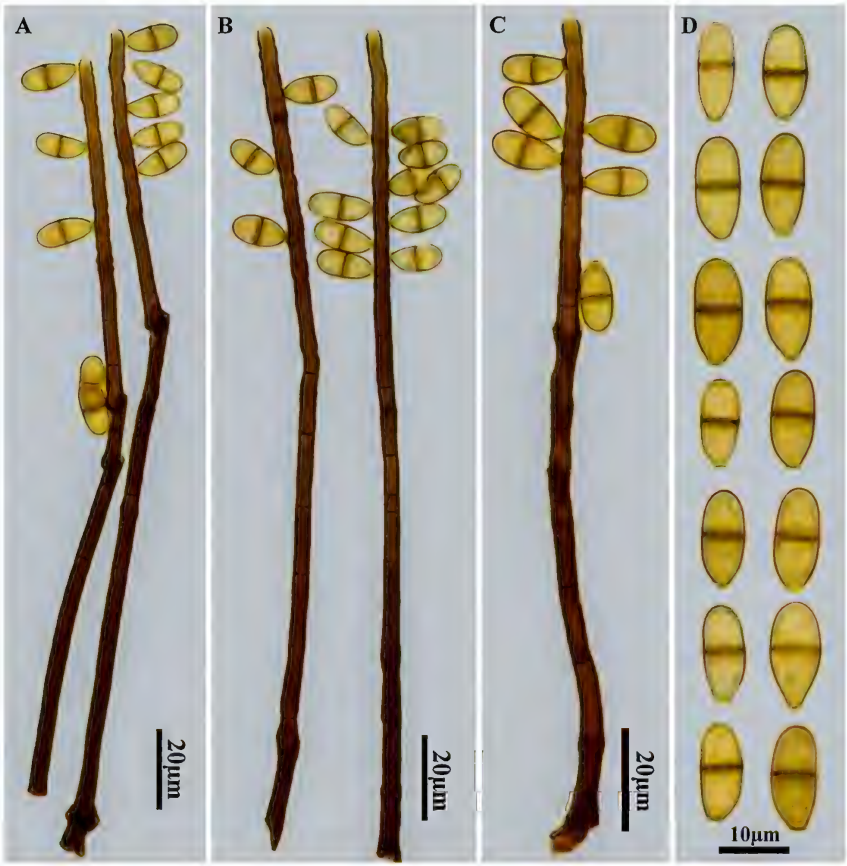

Fig. 5. *Endophragmiella cantabrica* (HJAUP M001).
A–C. Conidiophores, conidiogenous cells, and conidia; D. Conidia.

towards the apex, ≤220 × 3.5–4.5 μm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, brown, with ≤20 percurrent elongations. Conidial secession rhexolytic. Conidia solitary, acrogenous, oblong, ellipsoidal or sometimes obovoid, smooth, thick-walled, medially 1-euseptate, pale brown, 13–15.5 μm long, 5.5–7 μm diam. in the broadest part; apex rounded; base truncate, 2–2.5 μm diam., with a distinct 0.5–1 μm long basal frill derived from the distal end of the conidiogenous cell.

Specimen examined: **CHINA, Jiangxi Province**, Jinggangshan Mountain, on dead branches of an unidentified broadleaf tree, 16 October 2012, J. Ma (HJAUP M001).

Comments—Hernández-Restrepo & al. (2013) recorded this fungus on dead wood from Spain, and compared it with similar species, including *E. arranensis* P.M. Kirk, *E. bogoriensis* Rifai, *E. ovoidea* P.M. Kirk, and *E. uniseptata* var. *pusilla* Hol.-Jech. This is the first report of *E. cantabrica* in China. Our collection fits well with the original description of *E. cantabrica* except for our slightly larger conidia (cf. 10–14 × 5–6 µm; Hernández-Restrepo & al. 2013).

Endophragmiella ellisii P.M. Kirk, Index Fungorum 421: 1, 2019. Fig. 6

"*Endophragmia biseptata*" M.B. Ellis, Mycol. Pap.72: 31. 1959, nom. inval.

"*Endophragmiella ellisii*" S. Hughes, N.Z. J. Bot. 17(2): 150, 1979, nom. inval.

Conidiophores macronematous, mononematous, single or aggregated at the base, unbranched, erect, straight or flexuous, 4–9-septate, smooth, brown to dark brown, paler towards the apex, 70–140 × 5–6.5 µm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, pale brown, with

Fig. 6. *Endophragmiella ellisii* (HJAUP M0316).
A–C. Conidiophores, conidiogenous cells, and conidia; D. Conidia.

≤14 percurrent elongations. Conidial secession rhexolytic. Conidia solitary, acrogenous, obovoid to pyriform, smooth, thick-walled, 2-euseptate, the septum usually becoming darker and forming a band, distal cell brown to dark brown, central cell pale brown to brown and basal cell paler, 17.5–23.5 µm long, 8–11.5 µm diam. in the broadest part; apex rounded; base truncate, 2.5–3.5 µm diam., with a distinct 0.5–2 µm long basal frill derived from the distal end of the conidiogenous cell.

Specimens examined: **China, Jiangxi Province**, Jiulianshan National Nature Reserve, on dead branches of an unidentified broadleaf tree, 3 November 2014, J. Ma (HJAUP M0316); **Hainan Province**, Jianfengling National Nature Reserve, on dead branches of an unidentified broadleaf tree, 15 April 2015, J. Ma (HJAUP M0402).

Comments –The previous invalid publication of "*E. ellisii*" was validated in Senwanna (2019). This species has not previously been recorded from China. Our specimen overlaps well with the original descriptions of Ellis (1959). *Endophragmiella ellisii* is most similar to *E. bisbyi* B. Sutton ex P.M. Kirk (Senwanna 2019) and *E. hughesii* D. Hawksw. (Hawksworth 1979) in conidial shape, but *E. bisbyi* differs by its predominantly 3-euseptate, smaller conidia (12.5–16 × 6.3–7.6 µm; Hughes 1979), and *E. hughesii* differs by its larger conidia (25–30 × 11–13 µm) with a central pore at each septum (Hawksworth 1979).

Endophragmiella uniseptata M.B. Ellis ex P.M. Kirk, Index Fungorum 421: 1, 2019. Fig.7

"*Endophragmia uniseptata*" M.B. Ellis, Mycol. Pap.72: 28. 1959, nom. inval.

"*Endophragmiella uniseptata*" M.B. Ellis ex S. Hughes, N.Z. J. Bot. 17(2): 156, 1979, nom. inval.

Conidiophores macronematous, mononematous, single or aggregated at the base, unbranched, erect, straight or flexuous, 2–7-septate, smooth, brown to dark brown, 55–139 × 4–6 µm. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, smooth, pale brown to brown, determinate or with 1–3 percurrent elongations. Conidial secession rhexolytic. Conidia solitary, acrogenous, obovoid, smooth, 1-euseptate, the septum usually becoming darker and forming a band, brown to dark brown with the lower cell sometimes slightly paler, 15.5–21 µm long, 10–12.5 µm diam. in the broadest part; apex rounded; base truncate, 2.5–3.5 µm diam., with distinct 0.5–1 µm long basal frill derived from the distal end of the conidiogenous cell.

Specimen examined: **China, Guangdong Province**, Nanling National Nature Reserve, on dead branches of an unidentified broadleaf tree, 12 July 2014, J. Ma (HJAUP M0137).

Fig. 7. *Endophragmiella uniseptata* (HJAUP M0137).
A–C. Conidiophores, conidiogenous cells, and conidia; D, E. Conidiophores; F. Conidia.

Comments—Ellis (1959) reported this species on rotten wood of *Castanea saliva* and *Fagus sylvatica* from Great Britain. The previous invalid publication of "*E. uniseptata*" was validated in Senwanna (2019). *Endophragmiella uniseptata* is similar to *E. pinicola* M.B. Ellis ex P.M. Kirk (Senwanna 2019) in conidial shape, but *E. pinicola* has concolorous, smaller conidia (10–14 × 5–9 μm; Ellis 1976). Our collection corresponds well with the description of Ellis (1959; as "*Endophragmia uniseptata*") except for much fewer percurrent elongations of conidiogenous cells in our specimen (cf. up to 15; Ellis 1959). This is the first report of this species in China.

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Morphological and phylogenetic resolution of *Arthrinium* from medicinal plants in Yunnan, including *A. cordylines* and *A. pseudomarii* spp. nov.

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Abstract—Twenty-one strains of *Arthrinium* were cultured from leaf samples of ten medicinal plant hosts in Yunnan Province, China. Morphological and multi-locus ITS+TUB+TEF1 sequence analyses revealed that the strains represented two previously described species (*A. paraphaeospermum* and *A. rasikravindrae*) and two new species: *Arthrinium cordylines*, which produces subglobose conidia that are shorter and wider than *A. aureum* but larger than *A. hydei*, and *Arthrinium pseudomarii*, which produces subglobose to ellipsoid conidia narrower than *A. hispanicum*, *A. marii*, and *A. mediterranei.*

Key words—*Apiosporaceae*, phylogenetic analysis, taxonomy, *Xylariales*

Introduction

Arthrinium (*Apiosporaceae*, *Xylariales*, *Sordariomycetes*) is widely distributed around the world (Hyde & al. 2020). Its species often occur on different plant

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substrates as saprobes (Agut & Calvo 2004, Singh & al. 2013, Dai & al. 2016), pathogens (Martínez-Cano & al. 1992, Thangaraj & al. 2019), and endophytes (Ramos & al. 2010, Huang & Jiang 2015, Rashmi et al. 2019). *Arthrinium* is morphologically distinguished from other asexual genera by its basauxic conidiophores with terminal and intercalary polyblastic conidiogenous cells (Hughes 1953, Minter 1985, Hyde & al. 1998, Wijayawardene & al. 2016). However, it is impossible to resolve taxonomy within the genus without molecular data (Crous & Groenewald 2013).

During this study, we isolated 21 *Arthrinium* strains from leaves of ten different medicinal plants in Yunnan Province, China. Morphological and ITS + TUB + TEF1 sequence analyses clarified their taxonomic placements, revealing two previously described species (*A. paraphaeospermum* and *A. rasikravindrae*) and two new species, here proposed as *A. cordylines* and *A. pseudomarii*.

Materials & methods

Culture & morphology

Arthrinium strains were isolated from leaf samples collected from Yunnan Province, P.R. China, using the 'single-spore method' (Senanayake et al. 2020). Colonies were transferred to oat-agar (OA) and incubated at room temperature (c. 28 °C). Following 2–3 weeks of incubation, morphological characters were recorded. Conidial and conidiophore morphologies were examined using an Olympus BX53 compound microscope. The holotype specimens are deposited in the Herbarium of Department of Plant Pathology, Agricultural College, Guizhou University, China (HGUP), and pure cultures are deposited in the Department of Plant Pathology Culture Collection, Agriculture College, Guizhou University, China (GUCC), and isotype cultures of *Arthrinum cordylines* and *A. pseudomarii* are conserved in Guizhou Culture Collection (GZCC), Guizhou, China.

DNA amplification & sequencing

DNA amplification, sequencing and phylogenetic analysis follow Dissanayake & al. (2020) with modifications. Fungal cultures were grown on OA medium at 28 °C. When nearly covering the whole Petri-dish (90 mm diam), fresh mycelia were scraped from the surface with sterilized scalpels. Genomic DNA was extracted using a Biomiga Fungus Genomic DNA Extraction Kit (GD2416), following the manufacturers protocol. DNA was amplified in 25 µL reactions containing 2.5 µL 10 × PCR buffer, 1 µL of each primer (10 µM), 1 µL template DNA, and 0.25 µL Promega Taq DNA polymerase. Primers ITS4 and ITS5 (White & al. 1990) were used to amplify the ITS region, and Two protein-coding gene fragments (TUB and TEF1) were amplified by the primers T1/Bt2b (Glass & Donaldson 1995, O'Donnell & Cigelnik 1997) and EF1-728F/EF-2 (O'Donnell & al. 1998, Carbone & Kohn 1999).

Table 1 Sequences of *Arthrinium* spp. and *Nigrospora gorlenkoana* outgroup used for phylogenetic analyses

Species	Strain	GenBank accessions		
		ITS	TUB	TEF1
A. arundinis	CBS 114316	KF144884	KF144974	KF145016
A. aureum	CBS 244.83*	AB220251	KF144981	KF145023
A. bambusae	LC7106*	KY494718	KY705186	KY806204
A. camelliae-sinensis	LC5007*	KY494704	KY705173	KY705103
A. caricicola	AP23518	MK014871	MK017977	MK017948
A. cordylines	**GUCC 10026**	**MT040105**	**MT040147**	**MT040126**
	GUCC 10027*	**MT040106**	**MT040148**	**MT040127**
A. curvatum var. *minus*	AP25418	MK014872	MK017978	MK017949
A. descalsii	AP31118A*	MK014870	MK017976	MK017947
A. dichotomanthi	LC4950*	KY494697	KY705167	KY705096
A. esporlense	AP16717*	MK014878	MK017983	MK017954
A. euphorbiae	IMI 285638b	AB220241	AB220288	_
A. garethjonesii	HKAS 96289*	NR_154736	–	–
	JHB004	KY356086	–	–
A. guizhouense	LC5318	KY494708	KY705177	KY705107
	LC5322*	KY494709	KY705178	KY705108
A. gutiae	CBS 135835	KR011352	KR011350	KR011351
A. hispanicum	IMI 326877*	AB220242	AB220289	–
A. hydei	CBS 114990*	KF144890	KF144982	KF145024
	JHB0012	KY356087	–	–
	LC7103	KY494715	KY705183	KY705114
	LC7105	KY494717	KY705185	KY705116
A. hyphopodii	MFLUCC 15-0003*	KR069110	–	–
A. hysterinum	AP2410173	MK014876	–	–
A. ibericum	AP10118*	MK014879	MK017984	MK017955
A. italicum	AP221017*	MK014880	MK017985	MK017956
A. japonicum	IFO 30500	AB220262	AB220309	–
A. jatrophae	CBS 134262	NR_154675	–	–
	MMI 00052*	JQ246355	–	–
A. jiangxiense	LC4577*	KY494693	KY705163	KY705092
A. kogelbergense	CBS 113333*	KF144892	KF144984	KF145026
A. longistromum	MFLUCC 11-0481*	KU940141	–	–
	MFLUCC 11-0479*	KU940142	_	–
	MFLU 15-1184*	NR_154716	–	–
A. malaysianum	CBS 102053*	KF144896	KF144988	KF145030
A. marii	CBS 497.90*	AB220252	KF144993	KF145035
A. mediterranei	IMI 326875*	AB220243	AB220290	–
A. mytilomorphum	DAOM 214595*	KY494685	–	–
A. neosubglobosum	HKAS 96354	NR_154737	–	–
	JHB006	KY356089	–	–
	JHB007*	KY356090	–	–

A. obovatum	LC4940*	KY494696	KY705166	KY705095
A. ovatum	CBS 115042*	KF144903	KF144995	KF145037
A. paraphaeospermum	MFLUCC 13-0644*	KX822128	–	–
	GUCC 10124	**MT040108**	**MT040150**	**MT040129**
	GUCC 10125	**MT040109**	**MT040151**	**MT040130**
	GUCC 10126	**MT040110**	**MT040152**	**MT040131**
	GUCC 10127	**MT040111**	**MT040153**	**MT040132**
	GUCC 10128	**MT040112**	**MT040154**	**MT040133**
	GUCC 10129	**MT040113**	**MT040155**	**MT040134**
A. phaeospermum	CBS 114314	KF144904	KF144996	KF145038
A. phragmitis	CPC18900*	KF144909	KF145001	KF145043
A. piptatheri	AP4817A*	MK014893	–	MK017969
A. pseudomarii	**GUCC 10214**	**MT040114**	**MT040156**	**MT040135**
	GUCC 10221	**MT040115**	**MT040157**	**MT040136**
	GUCC 10225	**MT040116**	**MT040158**	**MT040137**
	GUCC 10263	**MT040117**	**MT040159**	**MT040138**
	GUCC 10254	**MT040118**	**MT040160**	**MT040139**
	GUCC 10259	**MT040119**	**MT040161**	**MT040140**
	GUCC 10260	**MT040120**	**MT040162**	**MT040141**
	GUCC 10270	**MT040121**	**MT040163**	**MT040142**
	GUCC 10226	**MT040122**	**MT040164**	**MT040143**
	GUCC 10227	**MT040123**	**MT040165**	**MT040144**
	GUCC 10228*	**MT040124**	**MT040166**	**MT040145**
	GUCC 10261	**MT040125**	**MT040167**	**MT040146**
A. pseudoparenchymaticum	LC7234*	KY494743	KY705211	KY705139
A. pseudosinense	CPC 21546*	KF144910	–	KF145044
A. pseudospegazzinii	CBS 102052*	KF144911	KF145002	KF145045
A. pterospermum	CPC 20193*	KF144913	KF145004	KF145046
A. puccinioides	AP26418	MK014894	MK017998	MK017970
	CBS 549.86	AB220253	AB220300	–
A. rasikravindrae	LC5449	KY494713	KY705182	KY705112
	LC8179	KY494759	KY705227	KY705155
	NFCCI 2144*	JF326454	–	–
	GUCC 10088	**MT040107**	**MT040149**	**MT040128**
A. sacchari	CBS 212.30	KF144916	KF145005	KF145047
A. saccharicola	CBS 191.73	KF144920	KF145009	KF145051
A. serenense	IMI 326869*	AB220250	AB220297	–
A. sporophleum	AP21118	MK014898	MK018001	MK017973
A. subglobosum	MFLUCC 11-0397*	KR069112	–	–
A. subroseum	LC7292*	KY494752	KY705220	KY705148
A. thailandicum	MFLUCC 15-0202*	KU940145	–	–
A. xenocordella	CBS 478.86*	KF144925	KF145013	KF145055
A. yunnanum	MFLUCC 15-0002*	KU940147	–	–
N. gorlenkoana	CBS 480.73	KX986048	KY019456	KY019420

* = ex-type strains. Strains and sequences generated in this study are shown in **bold**

The annealing temperatures were adjusted to 52 °C for ITS and TUB, and 56 °C for TEF1. The PCR amplicons were purified and sequenced by SinoGenoMax. The DNA sequences were submitted to GenBank (Table 1). The DNA base differences of different gene loci between our strains and ex-type strains of related taxa are shown in Table 2.

Phylogenetic analyses

DNA sequences from our strains and reference sequences downloaded from GenBank (Crous & Groenewald 2013, Dai & al. 2016, Wang & al. 2018, Pintos & al. 2019) were used for maximum parsimony (MP) and maximum likelihood (ML) analyses. Sequences in the order of ITS+TUB +TEF1 were aligned using an online version of MAFFT v. 7 (http://mafft.cbrc.jp/alignment/server/). Ambiguous

Table 2. DNA base differences in three gene regions comparing our *Arthrinium* sequences and sequences from related species.

Species	Strain	ITS (611)	TUB (752)	TEF1 (464)
Arthrinum cordylines	GUCC 10026*	0	0	0
	GUCC 10027	0	0	0
A. hydei	CBS 114990*	3	15	13
A. aureum	CBS 244.83*	3	24	19
A. rasikravindrae	GUCC 10088	0	0	0
	LC5449	1	4	0
A. paraphaeospermum	GUCC 10125	0	0	0
	GUCC 10124	15	0	0
	GUCC 10126	0	0	1
	GUCC 10127	0	0	0
	GUCC 10128	0	0	0
	GUCC 10129	0	0	3
	MFLU 13-0644*	0	\	\
A. pseudomarii	GUCC 10228*	0	0	0
	GUCC 10214	1	0	2
	GUCC 10221	0	2	2
	GUCC 10225	1	0	2
	GUCC 10263	1	0	2
	GUCC 10254	1	0	0
	GUCC 10259	1	0	0
	GUCC 10260	1	0	0
	GUCC 10270	1	0	0
	GUCC 10226	1	0	0
	GUCC 10227	0	0	1
	GUCC 10261	0	1	1
A. hispanicum	IMI 326877	1	2	\
A. marii	CBS 497.90	2	2	12
A. mediterranei	IMI 326875	1	2	\

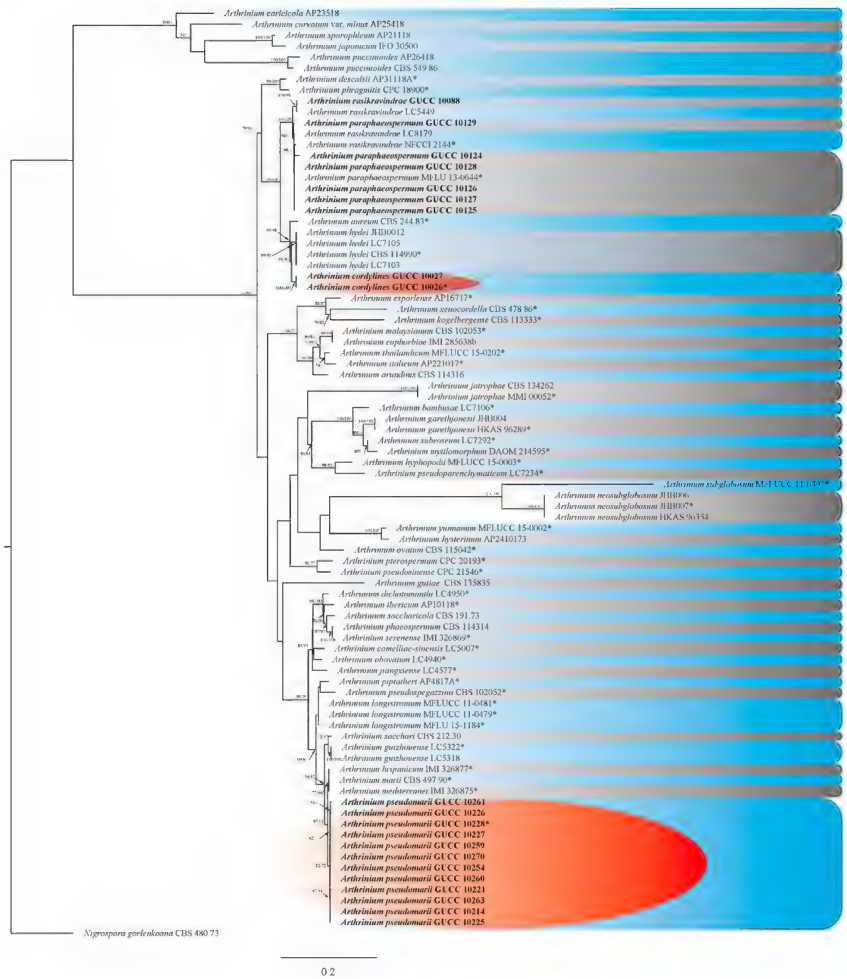

FIG. 1. Phylogenetic tree of *Arthrinium* spp., based on combined ITS, TUB, and TEF1 sequence alignments generated from maximum likelihood and maximum parsimony analyses. Bootstrap support values >50% are given at the nodes (ML/MP). The tree is rooted with *Nigrospora gorlenkoana* CBS 480.73. Ex-type strains are indicated with *. Bold entries represent newly sequenced strains. The new species are shown in bold and on a red background.

regions were excluded from the analyses, and gaps were treated as missing data. MP analyses were performed in PAUP v. 4.0b10 (Swofford 2002), using the heuristic search option with 1,000 random taxa addition and tree bisection and re-connection (TBR) as the branch swapping algorithm. Maxtrees = 5000 was

set to upbuild the phylogenetic tree. Tree Length (TL), Consistency Indices (CI), Retention Indices (RI), Rescaled Consistency Indices (RC), and Homoplasy Index (HI) were calculated for each tree. CIPRES Science Gateway (https://www.phylo.org/portal2/login.action) used the resulting Phylip file to generate the ML tree with GTRGAMMA as the nucleotide substitution model and RAxML-XSEDE with 1000 bootstrap inferences. DNA sequences generated with forward and reverse primers were used to obtain consensus sequences using MEGA v. 6.06 (Tamura & al. 2013). Sequences were aligned using MAFFT v7.307 online version (Katoh & Standley 2016) and edited by hand using MEGA v. 5.1.

Phylogenetic analytical results

Strain sequences comprised 480–633 bp (ITS), 460–477 bp (TEF1), and 701–829 bp (TUB) in length. Following alignment, the combined ITS+TUB +TEF1 dataset contained 2096 characters (ITS: 1–711 + TUB: 714–1246 + TUB: 1249–2096, adding two "N's" after the ITS and TEF1 sequences to distinguish between the two gene regions), of which 876 were parsimony-informative characters. Sequences from 50 *Arthrinium* species (representing 63 strains) were downloaded, plus the outgroup *Nigrospora gorlenkoana* Novobr. (CBS 480.73). Five thousand equally most parsimonious trees were obtained (TL = 3509, CI = 0.54, RI = 0.82, RC = 0.44, and HI = 0.46). Similar topologies were obtained by MP and ML methods, and the first equally most parsimonious tree was selected to display the phylogenetic relationship of *Arthrinium* species (Fig. 1). In Fig. 1, our strains clustered into three subclades: (1) GUCC 10026, GUCC 10027, *A. aureum* Calvo & Guarro, and *A. hydei* Crous; (2) GUCC 10214, GUCC 10221, GUCC 10225–10228, GUCC 10254, GUCC 10259–10261, GUCC 10263, and GUCC 10270 originated from five medicinal plants and formed a subclade with *A. hispanicum* Larrondo & Calvo, *A. marii* Larrondo & Calvo, and *A. mediterranei* Larrondo & Calvo; and (3) GUCC 10088 and GUCC 10124–10129 were adjacent to *A. paraphaeospermum* and *A. rasikravindrae*. All subclades are supported with high MP and ML bootstrap values (Fig. 1).

Taxonomy

Arthrinium cordylines T.Z Chen, Yong Wang bis & K.D. Hyde, **sp. nov.** Fig. 2

MB 834522

Differs from *Arthrinium aureum* by its shorter but wider conidia; and from *A. hydei* by its larger subglobose to ellipsoid conidia.

Typus: China, Yunnan Province, Xichuangbanna, from leaves of *Cordyline fruticosa* (L.) A. Chev. (*Asparagaceae*), 20.10.2018, leg. Y. Wang, (**Holotype**, HGUP 10027 [dried colony on OA]; ex-type culture, GUCC 10027; isotype culture, GZCC21-0020).

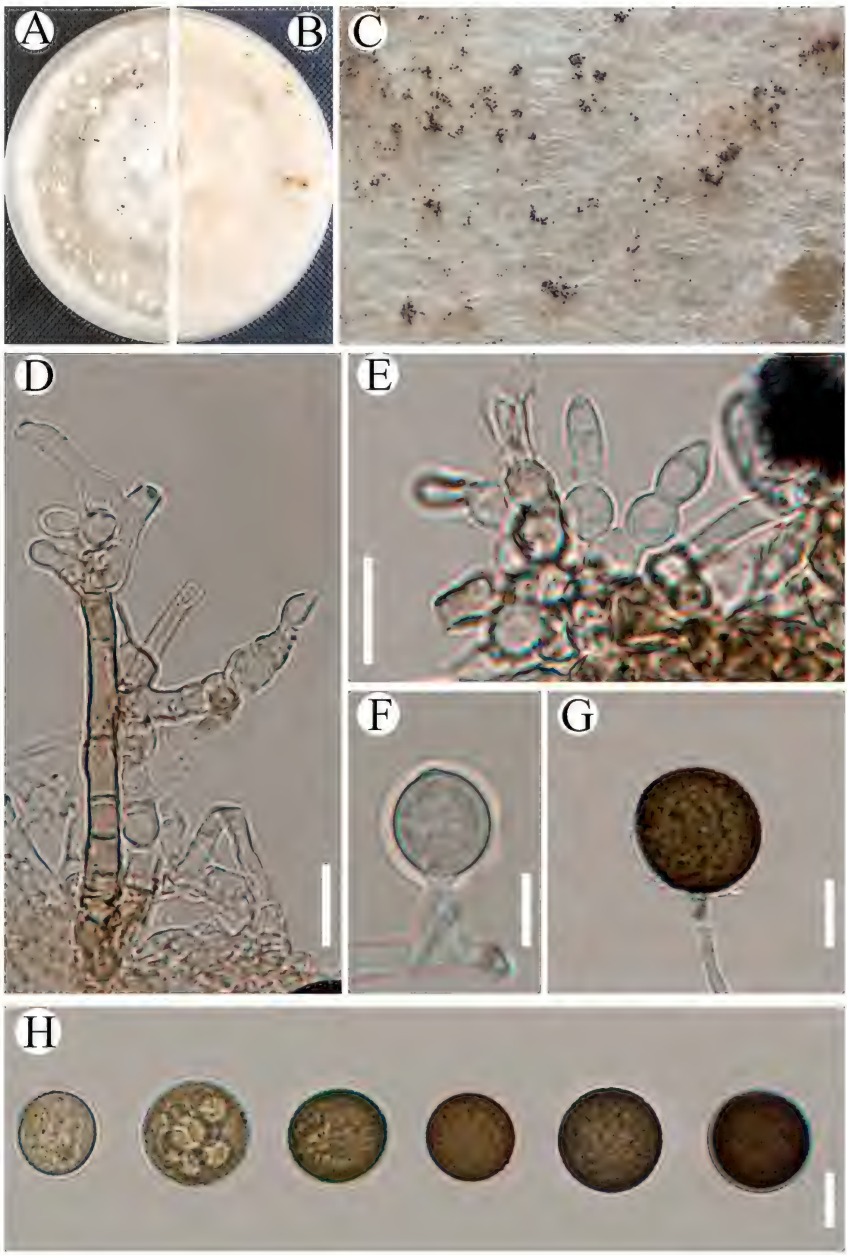

Fig. 2. *Arthrinium cordylines* (ex-holotype GUCC 10027). A. Host (*Cordyline fruticosa*) and symptoms; B, C. Cultures on OA; D. Colony on OA producing conidial masses; E–H. Conidiogenous cells giving rise to conidia; I Conidia. Scale bars: E, F, H, I = 10 μm; G = 5 μm.

Etymology: The specific epithet refers to the host *Cordyline fruticosa*, from which the fungus was isolated.

Hyphae hyaline, septate, branched, smooth, 1.5–2.5 µm diam. Conidiophores reduced to conidiogenous cells. Conidiogenous cells erect, aggregated into clusters on hyphae, hyaline to pale brown, smooth, doliiform to ampulliform or lageniform, (3–)5–10(–15) × 2.6–5.3 µm (av. 7.0 × 4.5 µm, n = 30). Conidia olivaceous to brown, smooth to finely roughened, subglobose to ellipsoid, 15–19 × 12.5–18.5 µm (av. 17.5 × 15.7 µm, n = 30).

Colonies on OA flat, spreading, circular, smooth at margin, with abundant aerial mycelia, surface and reverse white to grey, sometimes with light pink.

Teleomorph: not observed.

Additional material examined: **China: Yunnan Province, Xichuangbanna,** from leaves of *Cordyline fruticosa*, Y. Wang (HGUP 10026).

Notes—Our two strains (GUCC 10026, GUCC 10027) formed a branch with the ex-type strains of *A. aureum* (CBS 244.83) and *A. hydei* (CBS 114990) with 99% (MP) and 98% (ML) bootstrap support. *Arthrinium cordylines* also showed a close relationship to *A. hydei* (91% MP/80% ML). DNA pair-wise comparisons revealed three similar ITS, 13 similar TEF1, and 15 similar TUB base pairs, confirming that *A. cordylines* and *A. hydei* are separate species according to the guidelines of Jeewon & Hyde (2016). Morphologically, conidia in *A. cordylines* are shorter and wider than *A. aureum* (14–30 × 10–15 µm; Calvo & Guarro 1980) but larger than the globose conidia of *A. hydei* (11–12 µm diam; Crous & Groenewald 2013).

Arthrinium pseudomarii T.Z Chen, Yong Wang bis & K.D. Hyde, **sp. nov.** Fig. 3

MB 834523

Differs from *Arthrinium hispanicum*, *A. marii*, and *A. mediterranei* by its narrower subglobose to ellipsoid conidia.

Typus: China, Yunnan Province, Kunming Institute of Botany, from leaves of *Aristolochia debilis* Siebold & Zucc. (*Aristolochiaceae*), 15.1.2018, leg. X.B. Ming (**Holotype**, HGUP 10228 [dried colony on OA]; ex-type culture, GUCC 10228; isotype culture, GZCC21-0021).

Etymology: The specific epithet refers to the related species *Arthrinium marii.*

Hyphae hyaline, septate, branched, smooth, 2–3 µm diam. Conidiophores basauxic, mononematous, macronematous. Conidiogenous cells erect, aggregated into clusters on hyphae, hyaline to pale brown, smooth, doliiform to ampulliform, or lageniform, 8–13 × 2.5–5 µm (av. 6.0 × 4 µm, n = 30).

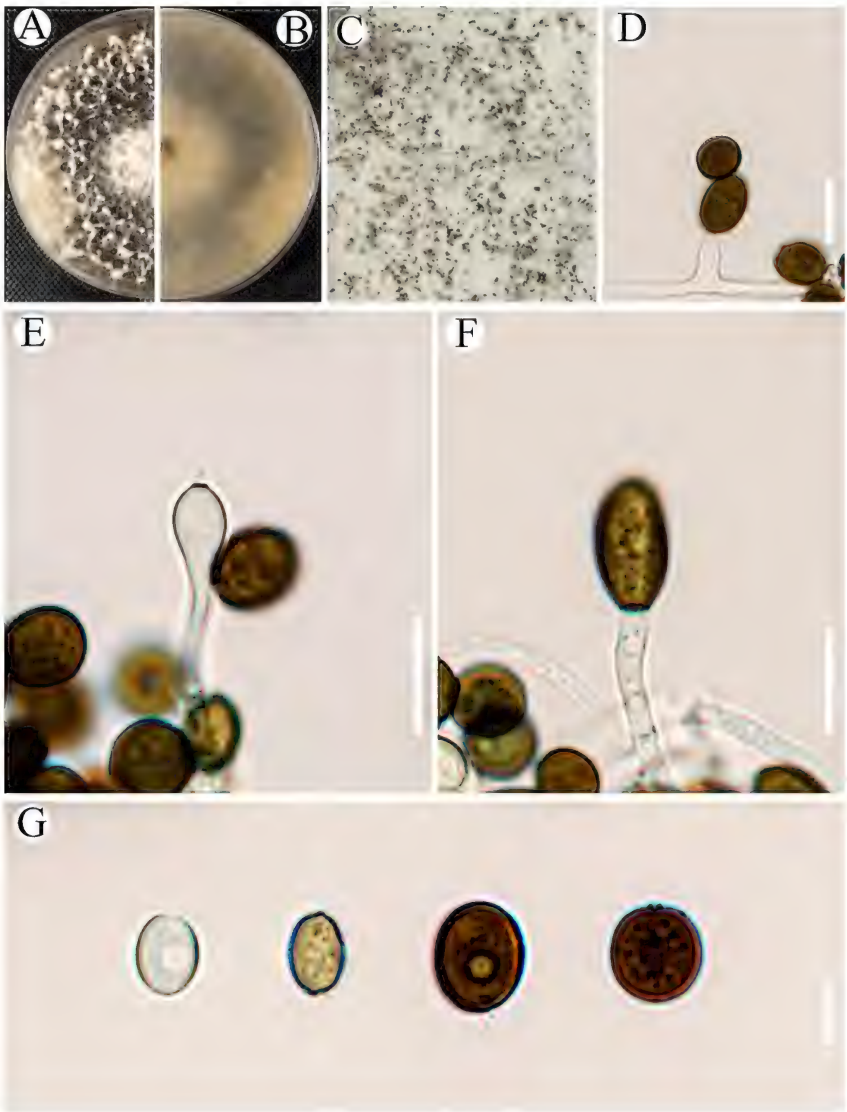

Fig. 3. *Arthrinium pseudomarii* (ex-holotype GUCC 10228). A. Host (*Aristolochia debilis*) and symptoms; B, C. Cultures on OA; D. Colony on OA producing conidial masses; E–G. Conidiogenous cells giving rise to conidia; H. Conidia. Scale bars: E–G = 20 μm; H = 5 μm.

Conidia solitary, lateral or terminal, olivaceous to brown, smooth to finely roughened, subglobose to ellipsoid, 6–9 × 4.5–6 μm (av. 7.7 × 5 μm, n = 30).

Colonies on OA, flat, spreading, margin circular, with abundant aerial mycelia, surface and reverse white to grey.

Teleomorph: not observed.

Additional material examined: **CHINA: Yunnan Province, Kunming Institute of Botany**, from leaves of *Pachysandra terminalis* Siebold & Zucc. (*Buxaceae*), Q. Zhang (GUCC 10214); from leaves of *Disporopsis pernyi* (Hua) Diels (*Asparagaceae*), H. Long (GUCC 10221); from leaves of *Aristolochia debilis*, X.B. Ming (GUCC 10225, GUCC 10226, GUCC 10227, GUCC 10261); from leaves of *Cordyline fruticosa*, X.B. Ming (GUCC 10263); from leaves of *Lycium chinense* Mill. (*Solanaceae*), X.B. Ming (GUCC 10254), from leaves of *Hosta ventricosa* Stearn (*Asparagaceae*), X.B. Ming (GUCC 10259, GUCC 10260); from leaves of *Epimedium acuminatum* Franch. (*Berbeidaceae*), X.B. Ming (GUCC 10270).

Notes—The twelve *Arthrinium pseudomarii* strains formed a relatively independent branch with 82% MP/72% ML support, which showed a close relationship to *A. hispanicum*, *A. marii*, and *A. mediterranei* with 95% MP/93% ML bootstrap support. We compared the DNA base pairs for three gene regions in the subclade (our twelve strains, *A. hispanicum*, *A. marii*, and *A. mediterranei*) which revealed that for *A. marii* there are 14–16 TEF1, 0–2 ITS. and 1–3 TUB differences (Table 2). There were 0–2 ITS base pair differences separating *A. hispanicum* and *A. mediterranei.* Morphologically, conidia in *A. pseudomarii* are narrower than conidia in *A. hispanicum* (7.5–8.5 × 6.2–7.6 µm), *A. marii* (7.2–7.5 × 6.1–6.5 µm), and *A. mediterranei* (9–9.5 × 7.5–9 µm) (Larrondo & Calvo 1990, 1992).

Arthrinium paraphaeospermum Senan. & K.D. Hyde,
Fungal Diversity 80: 198 (2016). Fig. 4

Hyphae hyaline, septate, branched, 3–5 µm diam. Conidiophores reduced to conidiogenous cells. Conidiogenous cells erect, aggregated into clusters on hyphae, hyaline to pale brown, smooth, elongated, conical to ampulliform, 15–30 × 3–5 µm (av. 19 × 4 µm, n = 30). Conidia olivaceous to brown, smooth to finely roughened, mostly subglobose, 9–15 µm (av. 13 µm, n = 30) diam.

Colonies on OA, flat, spreading, circular, smooth at margin with abundant aerial mycelia, surface and reverse white to grey, sometimes with light pink.

Teleomorph: not observed.

Material examined: **CHINA, Yunnan Province, Kunming Institute of Botany**, from leaves of *Epimedium sagittatum* (Siebold & Zucc.) Maxim. (*Berberidaceae*), 15.1.2018, leg. X.B. Ming (GUCC 10124–10127); from leaves of *Neocheiropteris palmatopedata* (Baker) Christ (*Polypodiaceae*), 15.1.2018, leg. X.B. Ming (GUCC 10128, GUCC 10129).

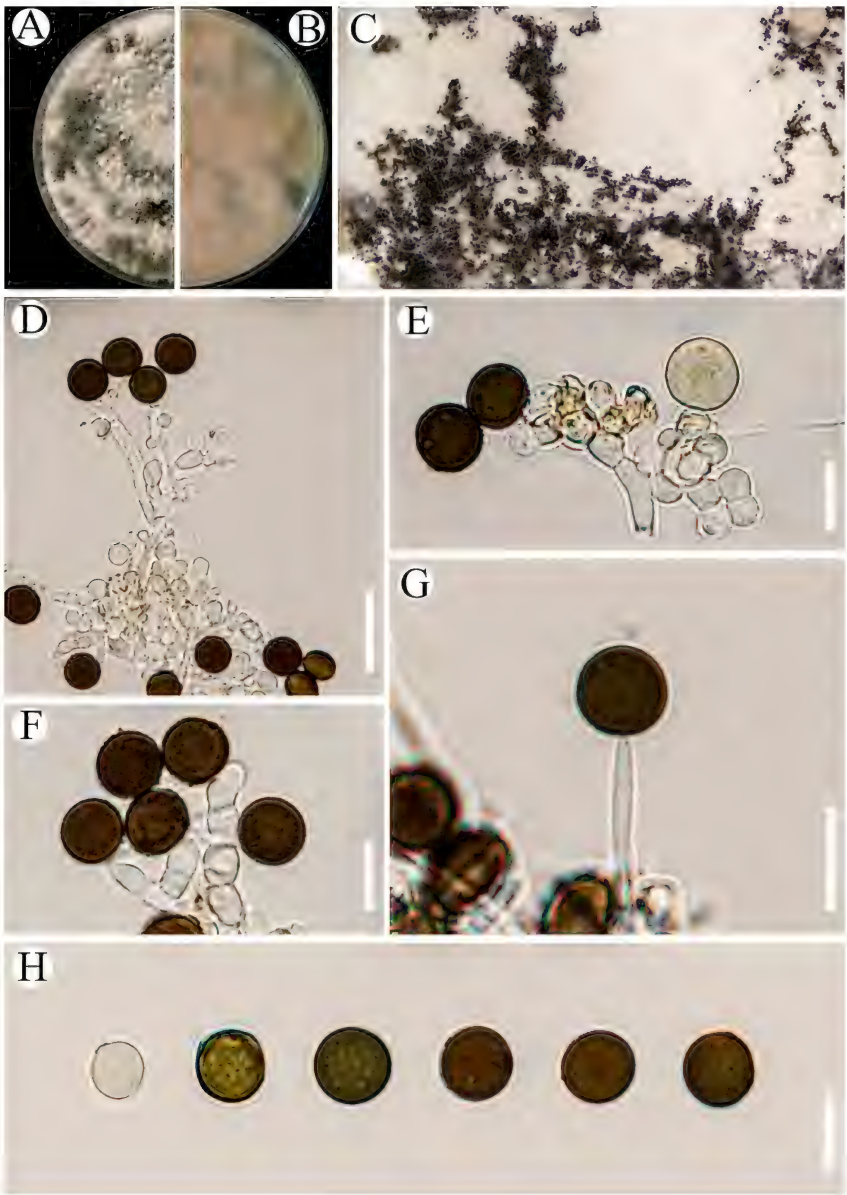

Fig. 4. *Arthrinium paraphaeospermum* (GUCC 10125). A. Host (*Epimedium sagittatum*) and symptoms; B, C. Cultures on OA; D. Colony on OA producing conidial masses; E–H. Conidiogenous cells giving rise to conidia; I. Conidia. Scale bars: E = 20 μm; E–I = 10 μm.

Notes—Phylogenetic group the six strains cited above with *A. paraphaeospermum* and *A. rasikravindrae*. Morphological comparison indicated that our strains were more similar to *A. paraphaeospermum*, in that the subglobose conidia differed from the dimorphous conidia of *A. rasikravindrae* (lenticular, ovoid: 10–15 × 6–10.5 µm; elongate to clavate: 15–25 × 7.5–10 µm; Singh & al. 2013, Hyde & al. 2016) and the subglobose to mainly ovoid conidia (8–13 × 6.5–11.5 µm) of GUCC 10088. Although GUCC 10124 showed 15 DNA base differences in the ITS region, the TUB and TEF1 sequences were nearly the same for all five strains (Table 2). Thus, we assign these collections to *A. paraphaeospermum*.

Arthrinium rasikravindrae Shiv M. Singh, L.S. Yadav, P.N. Singh, Rahul Sharma & S.K. Singh, Mycotaxon 122: 452 (2013 ["2012"]). Fig. 5

Hyphae hyaline, septate, branched, smooth, 2–3 µm diam. Conidiophores reduced to conidiogenous cells. Conidiogenous cells erect, aggregated in clusters on hyphae, hyaline to pale brown, smooth, doliiform to ampulliform, or lageniform, 10–20 × 3.5–5 µm (av. 14.0 × 4.0 µm, n = 30). Conidia arising acropleurogenously, olivaceous to brown, smooth to finely roughened, subglobose to mainly ovoid, 8–13 × 6.5–11.5 µm (av. 10.5 × 10 µm, n = 30).

Colonies on OA, flat, spreading, margin circular, with abundant aerial mycelia, surface and reverse white to grey, sometimes with light pink.

Teleomorph: not observed.

Material examined: **China, Yunnan Province, Kunming Institute of Botany,** from leaves of *Aspidistra elatior* Blume (*Asparagaceae*), 15.1.2018, leg. X.B. Ming (GUCC 10088).

Notes—Phylogenetic analyses (Fig. 1) confirmed that strain GUCC 10088 was closely related to *A. rasikravindrae* with high bootstrap support (MP = 100% / ML = 93%). DNA base pair comparison (Table 2) revealed only one ITS base pair difference as compared to representative culture of *A. rasikravindrae* (LC 5449), and no differences in the TUB and TEF1 sequences. Morphological comparison also indicated that GUCC 10088 represented *A. rasikravindrae* (Singh & al. 2013).

Discussion

Our regional survey of *Arthrinium* diversity in Yunnan Province revealed that *Arthrinium* was not host-specific, because the same species could be isolated from different plants (e.g., *A. paraphaeospermum* and *A. pseudomarii*), and strains of these two species possessed a very high base similarity in

Fig. 5. *Arthrinium rasikravindrae* (GUCC 10088). A. Host (*Aspidistra elatior*) and symptoms; B, C. Cultures on OA; D. Colony on OA producing conidial masses; E–I. Conidiogenous cells giving rise to conidia; J, K. Conidia. Scale bars: E, G = 10 μm; F, H–K = 5 μm.

different gene regions, which was consistent with Crous & Groenewald (2013) and Wang & al. (2018). Secondly, the discovery of four taxa suggests that *Arthrinium* is highly diverse in southwestern China, which would parallel the rich phyto-floristic diversity in this region. We also confirmed that morphological comparison alone is sufficient to identify *Arthrinium* taxa, and that sequence analysis with base comparison is essential to resolve species.

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Variability and distribution of *Pluteus luteus*, a later synonym of P. *variabilicolor*

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Abstract—The type specimen of *Pluteus luteus* was studied morphologically and molecularly using DNA sequences of the ITS region of the ribosomal RNA gene. *Pluteus luteus* is reduced to a synonym of *P. variabilicolor*, the morphological variability of which is discussed. The distribution of *P. variabilicolor* as a species native to Europe and Asia is summarized, including the first collection from Slovakia and the second report from the Republic of Korea (South Korea).

Key words—*Agaricales*, *Pluteaceae*, *Pluteus* sect. *Hispidoderma*, type studies, taxonomy

Introduction

Pluteus Fr. (*Agaricales*, *Pluteaceae*; Kotlaba & Pouzar 1972, Singer 1986, Justo & al. 2011a) is characterized by free lamellae, a pinkish spore print, smooth globose to ellipsoid (rarely oblong) basidiospores, an inverse hymenophoral trama, and the presence of cheilocystidia, often also pleurocystidia (Singer 1986, Vellinga 1990).

Traditionally, three sections are distinguished in the genus: *Pluteus* sect. *Pluteus*; *P.* sect. *Hispidoderma* Fayod; and *P.* sect. *Celluloderma* Fayod, divided into *P.* subsect. *Eucellulodermini* Singer and *P.* subsect. *Mixtini* Singer (Singer 1986). *Pluteus* sect. *Pluteus* is characterized by a pileipellis in the form of a cutis and thick-walled pleurocystidia with hooks, prongs or other types of excrescences; *P.* sect. *Hispidoderma* by a pileipellis consisting of elongated,

filiform or hyphal elements organized as a cutis, a hymeniderm or a trichoderm, and with non-metuloid pleurocystidia; and *P.* sect. *Celluloderma* by a pileipellis composed of relatively short (sphaeropedunculate, ellipsoid to saccate-obpyriform) elements organized with (*P.* subsect. *Mixtini*) or without (*P.* subsect. *Eucellulodermini*) longer elements, which may be interpreted as dermatocystidia or pileocystidia, as a hymeniderm, and non-metuloid pleurocystidia (Singer 1956, 1958, 1986; Orton 1986, Citérin & Eyssartier 1998). According to Justo & al. (2011a,b), these subsections are not natural groups, because elongated elements have appeared several times during the evolution of *P.* sect. *Celluloderma* and also some species with a cutis pileipellis (e.g., *P. fenzlii* (Schulzer) Corriol & P.-A. Moreau) are members of this section. Babos (1978) originally assigned *Pluteus variabilicolor* Babos to *P.* subsect. *Mixtini*. However, our phylogenetic analysis of nrDNA ITS sequences, in accordance with previous articles (Justo & al. 2011a, Lezzi & al. 2014), shows that it belongs to *P.* sect. *Hispidoderma*, together with *P. leoninus* (Schaeff.) P. Kumm. The explanation of this discrepancy is provided in this paper, based on micromorphological and phylogenetical studies.

Pluteus variabilicolor was described based on collections from Hungary, but the author pointed out that most of the species of *P.* subsect. *Mixtini* are non-European (Babos 1978). Later, *Pluteus castroae* Justo & E.F. Malysheva [as "*castri*"] described from Russia and Japan (Justo & al. 2011a: 470) was synonymized with *Pluteus variabilicolor* (Lezzi & al. 2014). *Pluteus luteus* was originally described as *Macrocystidia lutea* from China (Redhead & Liu 1982), but the authors stated *M. lutea* to be an anomalous species in *Macrocystidia* and after two years, Redhead (1984) transferred it to *Pluteus*.

In this paper, *Pluteus luteus* is reduced to a synonym under *P. variabilicolor*. The distribution of this species in Europe and Asia is summarized including the first collections from Slovakia and the second report from the Republic of Korea.

Materials & methods

Morphology

Macroscopic descriptions of the collected specimens are based on fresh basidiomata. Microscopic features were studied on dried material mounted in Congo red using an Olympus BX-50 light microscope at magnifications of 400× and 1000×. Herbarium abbreviations are according to Thiers (2019). Morphological terminology follows Vellinga (1988). Authors of fungal names are cited according to the Index Fungorum Authors of Fungal Names website (http://www.indexfungorum.org/names/AuthorsOfFungalNames.asp). Abbreviations: avl = mean of basidiospore length;

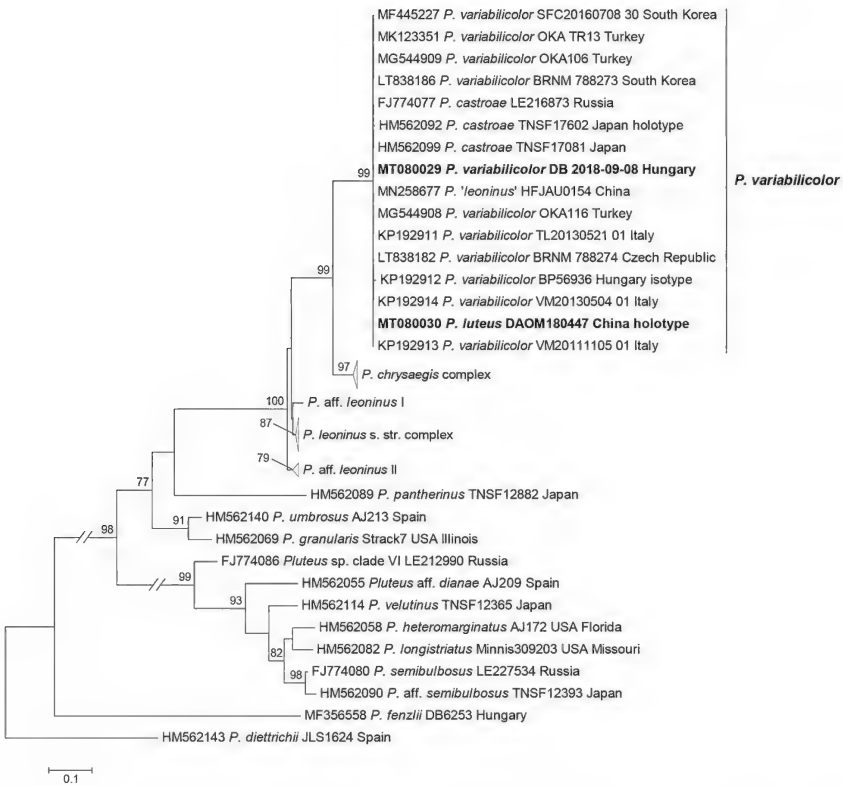
MF445227 P. variabilicolor SFC20160708 30 South Korea
MK123351 P. variabilicolor OKA TR13 Turkey
MG544909 P. variabilicolor OKA106 Turkey
LT838186 P. variabilicolor BRNM 788273 South Korea
FJ774077 P. castroae LE216873 Russia
HM562092 P. castroae TNSF17602 Japan holotype
HM562099 P. castroae TNSF17081 Japan
MT080029 P. variabilicolor DB 2018-09-08 Hungary
MN258677 P. 'leoninus' HFJAU0154 China
MG544908 P. variabilicolor OKA116 Turkey
KP192911 P. variabilicolor TL20130521 01 Italy
LT838182 P. variabilicolor BRNM 788274 Czech Republic
KP192912 P. variabilicolor BP56936 Hungary isotype
KP192914 P. variabilicolor VM20130504 01 Italy
MT080030 P. luteus DAOM180447 China holotype
KP192913 P. variabilicolor VM20111105 01 Italy
P. variabilicolor
P. chrysaegis complex
P. aff. leoninus I
P. leoninus s. str. complex
P. aff. leoninus II
HM562089 P. pantherinus TNSF12882 Japan
HM562140 P. umbrosus AJ213 Spain
HM562069 P. granularis Strack7 USA Illinois
FJ774086 Pluteus sp. clade VI LE212990 Russia
HM562055 Pluteus aff. dianae AJ209 Spain
HM562114 P. velutinus TNSF12365 Japan
HM562058 P. heteromarginatus AJ172 USA Florida
HM562082 P. longistriatus Minnis309203 USA Missouri
FJ774080 P. semibulbosus LE227534 Russia
HM562090 P. aff. semibulbosus TNSF12393 Japan
MF356558 P. fenzlii DB6253 Hungary
HM562143 P. diettrichii JLS1624 Spain
99
99
97
100
87
79
77
91
98
99
93
82
98
0.1

Fig. 1. Maximum likelihood phylogenetic tree inferred from nrDNA ITS data set, showing the relationships in *Pluteus* sect. *Hispidoderma*. Species complexes not dealt with in this study are shown as compressed clades. Newly generated sequences are highlighted in bold. PhyML bootstrap support values are shown at the branches. Bar indicates 0.1 expected change per site per branch.

avw = mean of basidiospore width; Q = quotient of length and width in any one basidiospore; avQ = mean of basidiospore Q-values.

Molecular phylogeny

For DNA extraction, only dried herbarium specimens were used. DNA was extracted with the NucleoSpin Plant II Mini Kit. PCR amplification of the internal transcribed spacer region (ITS) of the ribosomal RNA gene was performed with the primer pair ITS1F/ITS4 (White & al. 1990, Gardes & Bruns 1993). Sequencing of the amplicons was carried out with the same primers by LGC Genomics (Berlin, Germany). Chromatograms were checked and assembled with CodonCode Aligner 8.0.1. Initial BLAST search in the GenBank and UNITE nucleotide databases was performed to find homologous sequences. ITS sequences of *Pluteus* belonging to

P. sect. *Hispidoderma* were downloaded based on previous studies (e.g. Justo & al. 2011a, Lezzi & al. 2014). The names of HM562055 (*Pluteus* aff. *dianae*) and FJ774086 (*Pluteus* sp. clade VI) follow a previous taxonomic paper (Ševčíková & al. 2020). Sequences were aligned with the online version of MAFFT v. 7 using the E-INS-i algorithm (Katoh & Standley 2013). Alignment was inspected and edited with SeaView 4 (Gouy & al. 2010).

Maximum Likelihood analysis was performed in PhyML 3.1 (Guindon & Gascuel 2003) using the GTR+I+G model of evolution and gamma distribution of 8 rate categories. The resulting tree was edited in MEGA 7 (Kumar & al. 2016).

Phylogenetic results

The aligned ITS data set comprised a total of 40 sequences and a length of 700 positions including gaps which were treated as missing data in the ML analysis. Two new sequences were deposited in GenBank (MT080029 and MT080030). The resulting phylogram is shown in Fig. 1. Based on our analysis, the ITS sequence generated from the holotype of *Pluteus luteus* nests within the same clade including the holotype sequences of *Pluteus variabilicolor* and *P. castroae*, with high support (ML-BS = 99%). This clade forms a sister group of the *Pluteus chrysaegis* complex, as shown in Lezzi & al. (2014).

Taxonomy

Pluteus variabilicolor Babos,
Annales Historico-Natureles Musei Nationalis Hungarici 70: 93 (1978) Fig. 2, 4

= *Macrocystidia lutea* Redhead & B. Liu, Canadian Journal of Botany 60(8): 1485 (1982)
≡ *Pluteus luteus* (Redhead & B. Liu) Redhead, Sydowia 37: 266 (1984)
= *Pluteus castroae* Justo & E.F. Malysheva [as '*castri*'], in Justo & al., Mycological Progress 10(4): 470 (2011)

Type revision of *Pluteus luteus* Figs 2a, e–f; 3

Original description of *Macrocystidia lutea* — "Pileus 5–14 mm lat., campanulatus ad convexus umbone, humidus, translucidus, glabratus, levis, luteus, in sicco infuscato. Lamellae adnatae, ascendens, latae, confertae, albae, in siccis salmoneis. Stipes 12–60 × 1–1.3 mm, levis, albus, in sicco ochraceo. Basidiosporae 5–6 × 4–5.8 µm, subglobosae, angulatus obscure, subhyalinae ad subsalmoneus, inamyloideae, leves, cyanophilae praecipue. Basidia tetraspora, clavata. Cheilocystidia et pleurocystidia 42–57 × 11–22 µm, dispersa, fusiformia ad ventricosa, levia. Pileocystidia abundant, clavata ad ventricosa, levia, implexa, 28–52 × 1 1–14 µm. Caulocystidia apiceum versus, aggregata, clavata ut mucronata interdum. Hyphae fibulis nullis. *Lactocollybia* affinis."

Fig. 2. *Pluteus variabilicolor*, pileipellis elements. a. DAOM 180447, holotype of *P. luteus,* young basidioma; b. BRNM 788274; c. BRNM 772177; d. BRNM 788273; e, f. DAOM 180447, holotype of *P. luteus,* mature basidioma. Scale bars = 10 µm.

a
b
c
d
e
f

Holotypus—China, Kiangsu Province, Nanking City, June 27, 1978, Liu Bo 432, on rotting wood in mountains (DAOM 180447).

Basidiospores 5–6.5(–7.5) × (4–)4.5–6 µm, avl × avw = 5.9 × 5.1 µm, Q = 1.00–1.40, avQ = 1.16, subglobose, rarely broadly ellipsoid or globose with small inconspicuous apices. Basidia 20–31(–33) × 6–8(–11) µm, tetrasterigmate, clavate to subfusiform or narrowly utriform, colourless. Pleurocystidia abundant, 40–51.5(–78) × 11–19(–24) µm, clavate to broadly clavate, with obtuse or slightly acuminate apex, narrowly to broadly fusiform, less frequently narrowly lageniform or narrowly utriform, with obtuse apex or rarely with small rostrate apex, hyaline, thin-walled. Lamellar edges sterile. Cheilocystidia (22–)31–52 × (7–)10.5–22 µm, narrowly to broadly fusiform, with obtuse apex or rarely with 1–4 µm long rostrate apex, or clavate to broadly clavate, with obtuse or slightly acuminate apex, less frequently narrowly lageniform or narrowly utriform, very rarely with 1–3 µm long rostrate apex, hyaline, thin-walled. Pileipellis a euhymeniderm composed of two types of elements: [1] (17–)20–54(–57) × 11–17(–19.5) µm, narrowly clavate to clavate, narrowly fusiform to fusiform, frequently with obtuse apex or 1–4 µm long (sub)rostrate apex; [2] (120–)181–210(–220) × 8–16 µm elongate (sub)cylindrical elements with obtuse apex; both types with yellow or pale yellow-ochre intracellular pigment, less frequently almost colourless with very pale yellow tinge, thin-walled. Stipitipellis a cutis of 4–12(–16) µm diam cylindrical thin-walled, colourless or pale ochre-coloured hyphae. Caulocystidia in tufts, more frequently in lower part of stipe, 14–30(–42) × 4–11(–19.5) µm, subcylindrical, narrowly clavate to broadly clavate, fusiform or utriform, often with 1–4 µm long rostrate apex, thin-walled, colourless, in lower part of mature basidioma with brown intracellular pigment. Clamp connections absent from all tissues.

Distribution and ecology

So far *Pluteus variabilicolor* is known from Europe: Hungary (Babos 1978), Austria (Lohmeyer & al. 1994), Italy (Lanconelli & al. 1998, Migliozzi 2011, Lezzi & al. 2014), Spain (Sánchez & Muñoz 2018), Romania (BRA 32267, Béres 2012), Slovenia and Moldova (Lezzi & al. 2014), and Russia (Justo & al. 2011a) – and from Asia: Japan (Justo & al. 2011a), China (as *P. luteus*; Redhead & Liu 1982, Redhead 1984), and the Republic of Korea (as *P. luteus*; Lee & al. 2016). A second collection from the Republic of Korea is reported from a dead trunk of *Castanea* in a mixed forest (BRNM 788273). *Pluteus variabilicolor* was found for the first time in Slovakia at two localities, one on a heap of sawdust and the other on decayed wood of a deciduous tree in a deciduous forest (BRNM 788274, BRNM 772177). This species is probably widespread but rare in

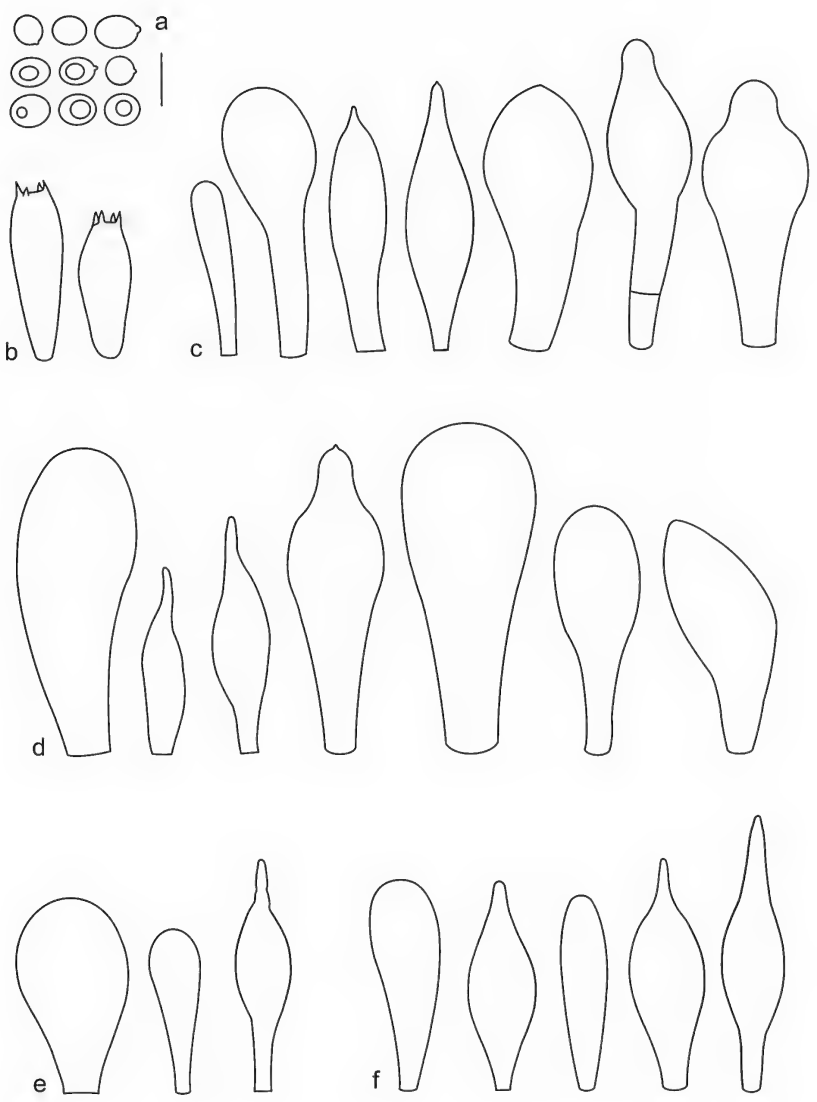

Fig. 3. *Pluteus luteus* (holotype, DAOM 180447). a. basidiospores; b. basidia; c. cheilocystidia; d. pleurocystidia; e. caulocystidia of young basidioma; f. caulocystidia of mature basidioma. Scale bar = 10 µm.

Europe and Asia, growing on decayed wood (mostly fallen trunks), sawdust, or woodchips of deciduous trees from May to October (BRNM 772177, BRNM 788273, BRNM 788274, Babos 1978, Béres 2012, Justo & al. 2011a, Lanconelli & al. 1998, Lezzi & al. 2014, Lohmeyer & al. 1994, Migliozzi 2011, Redhead & Liu 1982, Redhead 1984, Sánchez & Muñoz 2018).

Discussion

Phylogenetically, the lineage of *Pluteus variabilicolor* [= *P. luteus*; = *P. castroae*] forms a uniform and isolated clade, supported by our ML analysis of the ITS dataset. The sequence variation among the specimens studied was low: 1–6 substitution or indel positions. However, most of these variations originated from polymorphic sites and might not be real differences. (These sequences contain uncertain positions, where base polymorphisms occur, marked with IUB codes. Therefore, these cannot be counted as real differences with certainty.) The closest sister taxon, the *P. chrysaegis* complex, differs by more than 50 substitution and indel positions.

Pluteus luteus was originally described as *Macrocystidia lutea*. Redhead & Liu (1982) mentioned ascending adnate lamellae, whereas the genus *Pluteus* is characteristic by free lamellae. Redhead (1984), who had never seen fresh material, later revised the description from the type collection and combined the name with *Pluteus* to draw attention to the original misclassification. Redhead based the reclassification upon the convergent pluteoid tramal structure and a more palisade-like nature of the pileipellis on the disc but did not mention the attachment of the lamellae. The type material contains one larger and several small young basidiomata on which the lamellar attachment is not clear. After cutting the basidioma, we observed that the lamellae appear to be free.

Pluteus variabilicolor is, as its name implies, a variable species. Babos (1978) mentioned a white (or yellowish) stipe with dark floccules (as in *Leccinum*), sometimes only on the basal part of the stipe or as inconspicuous floccules visible only with a lens. Liu described *Pluteus luteus* as having a white stipe when fresh, turning ochraceous on drying (Redhead & Liu 1982). In our type studies (DAOM 180447!), we found only rare tufts of brownish caulocystidia in the lower part of the stipe of a mature basidioma and scattered colourless caulocystidia in the upper part. Therefore, the dark floccules on the stipe are not a significant feature for identification of *P. variabilicolor*. Moreover, the stipes of the Slovakian collection BRNM 788274 (relatively young basidiomata) have yellow-ochre to mustard yellow fibrils on a white background, and brown on white background in the lower part, at least at the stipe base (see Fig. 4).

Fig. 4. *Pluteus variabilicolor*, basidiomata. a–c. BRNM 788274 (photo J. Pavlík); d. BRNM 788273 (photo V. Antonín); e. BRNM 772177 (photo J. Hraško); f. BRNM 817743 (photo D. Solár).

Babos (1978) cited various pileus colours for the young basidiomata: lemon-, chrome- or orange-yellow, sometimes with mustard to brownish green tinges, paler at the pileus margin, and brown or grey-brown fibrillose scales.

The Slovak and South Korean collections (BRNM 788274; BRNM 772177; BRNM 788273; see Fig. 4) confirm this variability.

Lezzi & al. (2014) mentioned a difference in the pileipellis structure between the original description of *P. variabilicolor* and the Italian collections identified originally as *P. castroae;* phylogenetically they were identical and synonymized under *P. variabilicolor.* According to Lezzi & al. (2014), Italian collections lack the elongated pileipellis elements (up to 200 µm long) found in collections of *P. variabilicolor*. Our holotype studies show that elongate elements of up to 210 µm are frequent in mature basidiomata (BP85860, isotype of *P. variabilicolor*; large basidioma labelled as the holotype of *P. luteus*, DAOM 180447; also BRNM 788274, etc.). Shorter elements dominate in young basidiomata (BRNM 788273; small basidiomata of DAOM 180447, etc.); elongate elements are very rare and inconspicuous and thus may, in some cases, look like subpellis elements. The long elements also prevail at the pileus margin. In some cases, long elements are absent at least in middle parts of the pileus of very young basidiomata (the smallest basidioma of DAOM 180447; LE 212090).

Pluteus variabilicolor was initially included within *P.* subsect. *Mixtini* (Babos 1978) but belongs phylogenetically to *P.* sect. *Hispidoderma* (Justo & al. 2011a, Lezzi & al. 2014, our studies – see Fig. 1). Moreover, our morphological studies of the type show that the pileipellis structure of *P.* subsect. *Mixtini* within the traditional *P.* sect. *Celluloderma* differs significantly from the pileipellis structure of species belonging phylogenetically to *P.* sect. *Hispidoderma*. Singer (1986) pointed out that the pileipellis of *P.* subsect. *Mixtini* is based on short (ellipsoid to saccate-obpyriform) elements, and elongate elements can be interpreted as dermatocystidia (= pileocystidia). By contrast, a pileipellis formed of long elements is typical of species belonging to *P.* sect. *Hispidoderma*. Thus, the long elements of *P. variabilicolor* probably form the pileipellis as well as the shorter elements. Our morphological studies show that the long elements grow later during basidioma ontogenesis, which is a very unusual phenomenon in *Pluteus*. Further investigation of the growth dynamics of the pileipellis is needed.

Babos (1978) and Courtecuisse (2006) mentioned *Pluteus variabilicolor* as possibly introduced into Europe. The new records from Slovakia and South Korea confirm that this species is widespread in Eurasia and supports the theory that *P. variabilicolor* is a native species in the temperate zone of Europe and Asia.

Collections studied—***Pluteus variabilicolor***: **HUNGARY.** Prope Szárliget, in heap of sawdust, 6 July 1977, leg. M. Babos et A. Friesz, det. M. Babos (BP85860 isotype); 19 Aug. 1974, leg. E. Véssey, det. M. Babos (BP56982); Budai Mts, Mt. Jánoshegy, on rotten trunk, 19 June 1960, leg. I. Szőke, det. M. Babos (BP34357); Visegrádi Mts, Dömös, Malom-patak, in heap of sawdust, 23 July 1968, leg. et det. M. Babos (BP47697); Solymár; in heap of sawdust, 3 Sept. 1977, leg. K. Tallér, det. M. Babos (BP56990). **AUSTRIA.** Tittmining-Ettenau, heap of bark mulch (*Populus*?), 30 Oct. 1993, leg. R. Till et T.R. Lohmeyer, det. H. Forstinger (L 7942/2). **ROMANIA.** Moraresti, near Lintesti, decaying sawdust of Quercus, 3 June 1979 leg. et det. J. Kuthan (BRA 32267). **SLOVAKIA.** Snina, Hrb, heap of sawdust, 10 May 2010, leg. J. Pavlík, det. H. Ševčíková (BRNM 788274); Mládzovo, Hlonča, deciduous forest, on decayed wood of deciduous tree, 21 Oct. 2015, leg. J. Hraško, det. H. Ševčíková (BRNM 772177); Lošonec, Lošonský háj, on trunk of *Quercus*, 13 September 2019 leg. D. Solár, det. H. Ševčíková (BRNM 817743). **REPUBLIC OF KOREA.** Taean Peninsula, Deoksung, Sudeoksa Monastery, mixed forest, dead trunk of *Castanea*, 7 Aug. 2014, leg. V. Antonín, det. H. Ševčíková (BRNM 788273).

Pluteus variabilicolor [originally as ***P. castroae***]: **RUSSIA.** Samara Region, near Pribrezhny, on decaying wood of deciduous tree, 1 July 2007, leg. et det. E.F. Malysheva (LE 212090, paratype).

Pluteus variabilicolor [originally as ***P. luteus***]: **CHINA.** Kiangsu Province, Nanking City, on rotting wood in mountains, 27 June 1978, leg. B. Liu (DAOM 180447, holotype).

Pluteus fenzlii [originally as ***P. variabilicolor***]: **HUNGARY.** Vas, Hosszúpereszteg, on heap of sawdust, 7 Oct. 1990, leg. P. Serediuk, det. J. Borovička (BP 88763).

Conclusions

According to our results, *Pluteus luteus* (as well as *P. castroae*) is a synonym of *P. variabilicolor* and belongs to *P.* sect. *Hispidoderma*. This taxon is macroscopically and microscopically variable in colour and in structure of pileus and stipe. The most significant characters of *P. variabilicolor* are its yellow to ochre pileus, mostly clavate or fusiform thin-walled pleurocystidia and cheilocystidia often with an obtuse apex or rostrum. Pileipellis structure is also important for distinguishing *P. variabilicolor* from other species, but this character changes during the growth of the basidiomata. The shorter elements prevail over the long elements in the pileipellis of very young basidiomata in our studied collections. With aging basidiomata, however, this ratio significantly changes even in one population. A stipe with conspicuous dark floccules on a white ground is not a stable character. The stipe may also be white without conspicuous floccules; the lower part of the stipe may also have a yellow colour. *Pluteus variabilicolor* is rare but widespread in Europe and Asia on decayed wood, sawdust, or woodchips of deciduous trees. Its distribution indicates it is native to temperate Eurasia.

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Dichotomophthora portulacae, a new record from Iraq

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Abstract—*Dichotomophthora portulacae* isolated from *Portulaca oleracea* is newly recorded from Iraq. The ITS sequence showed congruence with *D. portulacae* sequences deposited in GenBank. A phylogram, description, and illustrations are provided.

key words—conidial fungi, taxonomy, plant pathogenic fungi

Introduction

Dichotomophthora was described by Mehrlich & Fitzpatrick with the single species *D. portulacae* isolated from *Portulaca oleracea* in Hawaii. *Dichotomophthora portulacae* causes diseases on the succulent weed purslane, *Portulaca oleracea* (Mehrlich & Fitzpatrick 1935, Ellis 1971). The fungus produces a necrotic leaf spot and dark lesions on stems (Klisiewicz 1985, Klisiewicz & al. 1983).

Materials & methods

Fungal isolation, culture, and observation

Samples were collected from *Portulaca oleracea* in Basra Governorate, Iraq. Pieces of stems and leaves with disease symptoms were surface disinfected in 3% sodium hypochlorite for 5 min, rinsed in sterile distilled water, and plated on water agar. Hyphae originating from these tissue pieces were transferred to potato dextrose agar (PDA). Morphological characteristics such as conidiophore length, conidial dimension, and sclerotial dimension were measured at 40× magnification. Cultural characteristics such as colony appearance, conidial shape, colour and shape of

sclerotia over the plate were also examined. The living culture, slant tube, and dried agar plate are conserved in the author's private herbarium "herb. Z.K. Abdulla."

DNA extraction, amplification, and sequence analysis

A monoconidial culture was grown on PDA for 10 days at 27 °C and mycelium was harvested by scraping the culture using a sterile scalpel. Genomic DNA was extracted from mycelium by using Ez-10 Spin Column Fungal Genomic DNA Mini-Preps Kit. PCR amplification was performed in a 50 µl total volume containing 10 µl DNA template, 25 µl master mix, 11 µl nuclease-free water, and 2 µl of ITS 1 and ITS4 primers (White & al. 1990). PCR was performed in an Eppendorf Thermal Cycler following the protocol: 1 cycle of 3 min denaturation at 94 °C, then 35 cycles of 40 sec at 94 °C, 60 sec at 55 °C, 60 sec at 72 °C, and ending with one 10 min final extension at 72 °C. The amplified product was checked by electrophoresis on 2% agarose gel in 1 × TBE (trisBorate) buffer stained with ethidium bromide (1mg/L) and visualized under UV light.

For sequencing, the PCR product was purified with Gen All in One Combo Kit according to the manufacturer's instructions and sequenced by Macrogen using with ABI prism 3700 sequencers. The sequences were analysed using DNA Dragon (http://www.sequentix.de/dnadragon.) and GenBank's BLAST program (http://blast.ncbi.nlm.nih.gov).

Taxonomy

Dichotomophthora portulacae Mehrl. & Fitzp. ex M.B. Ellis, Demat. Hyphomyc.: 388 (1971) Fig. 1

Colonies on PDA were effuse, greyish brown, hairy, or velvety, producing red pigment into the media. Mycelium was superficial and sometimes immersed, composed of smooth, branched, brown hyphae. Sclerotia spherical to globose or irregular, dark brown or black non-solid 180–280 × 180–220 µm. Conidiophores macronematous, mononematous, erect, cylindrical below, dichotomously or trichotomously branched, brown or hyaline, branches ≤400 µm long, 6–10 µm thick. Conidiogenous cells polytretic, lobed, discrete, determinate. Conidia solitary, cylindrical clavate, straight, round at the ends, smooth or verruculose, 17.5–55 × 10–15 µm, 1–4-septate, hyaline or pale brown, with a dark scar at the conidiogenous locus.

Specimen examined: **IRAQ, Basrah Province, Al Jazeera:** on stems and leaves of *Portulaca oleracea* L. (*Portulacaceae*), 15 Mar 2014, coll. Z.K. Abdulla (herb. Z.K. Abdulla ZKA1; strain ZAI1; GenBank MN508373).

Discussion

The Iraqi *Dichotomophthora portulacae* isolate resembled that described by Ellis (1971) except that the Iraqi conidia were smaller with 1–4 transverse

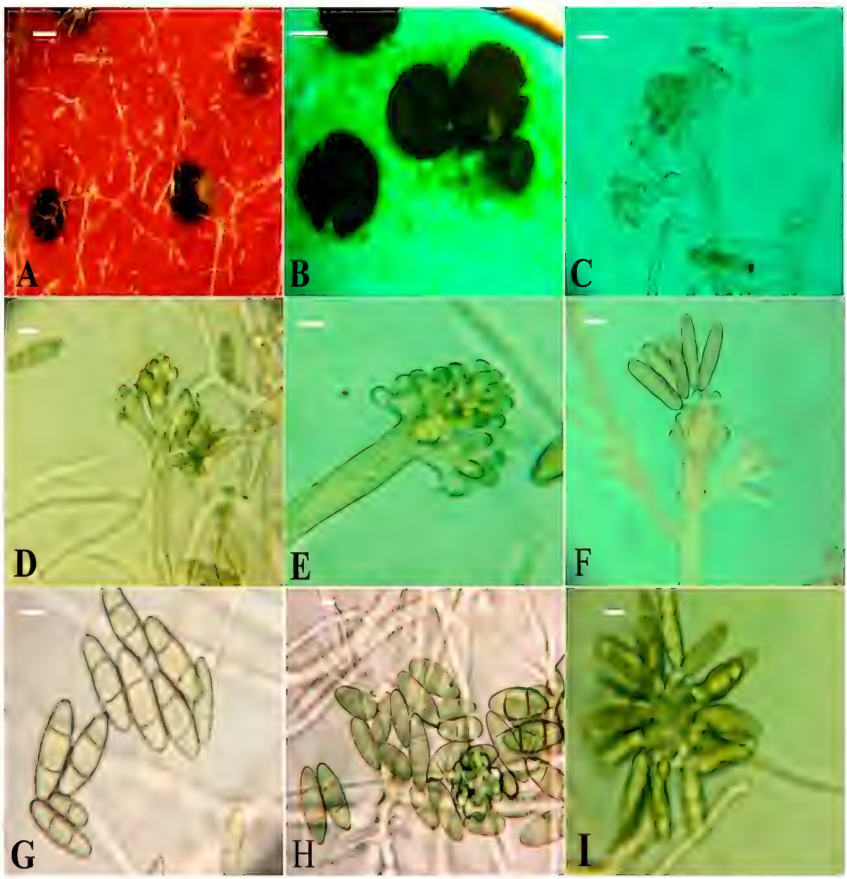

Fig. 1. *Dichotomophthora portulacae* (herb. Abdulla ZKA1). A, B. Sclerotia; C, D. Branched conidiophores; E. Lobed conidiophore; F–I. Conidia. Scale bars: A, B = 100 µm; C–I = 10 µm

septa and the conidiophores were usually dichotomously or trichotomously branched. The cultures produced pigment that converted the PDA to scarlet red after a few days. The morphological characters otherwise matched those of *D. portulacae,* and the culture's ITS sequence confirmed this identification. *Dichotomophthora portulacae* was isolated by Eken (2003) from *Portulaca oleracea* in Turkey and by Jing & al. (2008) from *Basella rubra* L. in China. The *Dichotomophthora* sp. isolated by Soares & Nechet (2017) from *Anredera cordifolia* (Ten.) Steenis in Brazil was identified based on morphology as

D. lutea; analysis of its ITS sequence showed high homology with a GenBank sequence labelled as "*Bipolaris* sp."

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Myxomycetes in the Pantanal biome: first records and a new associate, *Attalea phalerata*

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Abstract—The occurrence of myxomycetes is reported for the first time in the Brazilian Pantanal and on *Attalea phalerata* (acuri palm). The records are based on sporocarp collections made in the municipality of Poconé, State of Mato Grosso, in an area characterized by seasonal hydrological fluctuations and naturally open areas. We report six species: *Arcyria obvelata*, *Perichaena depressa*, and *P. vermicularis* (*Trichiaceae*); and *Physarum album, P. compressum,* and *P. polycephalum* (*Physaraceae*), all of which represent new records for the Pantanal and a new substrate, *A. phalerata*.

Keywords—geographic distribution, *Mycetozoa*, myxobiota

Introduction

The Pantanal is considered the largest floodplain in the world (>140,000 km²). It is located in the central region of South America, extended in Bolivia, Paraguay, and Brazil. Considered the smallest Brazilian biome, the Pantanal lies in the Central-West region of the country in the States of Mato Grosso and Mato Grosso do Sul (Prance & Schaller 1982, Ribeiro & Dias 2007). According to the Köppen classification, its climate is AW: predominantly tropical with hot humid summers and cold dry winters, with annual temperature and precipitation averaging 25 °C and 140 cm (Signor & al. 2010, Alvares & al. 2013). The floods vary between permanent and

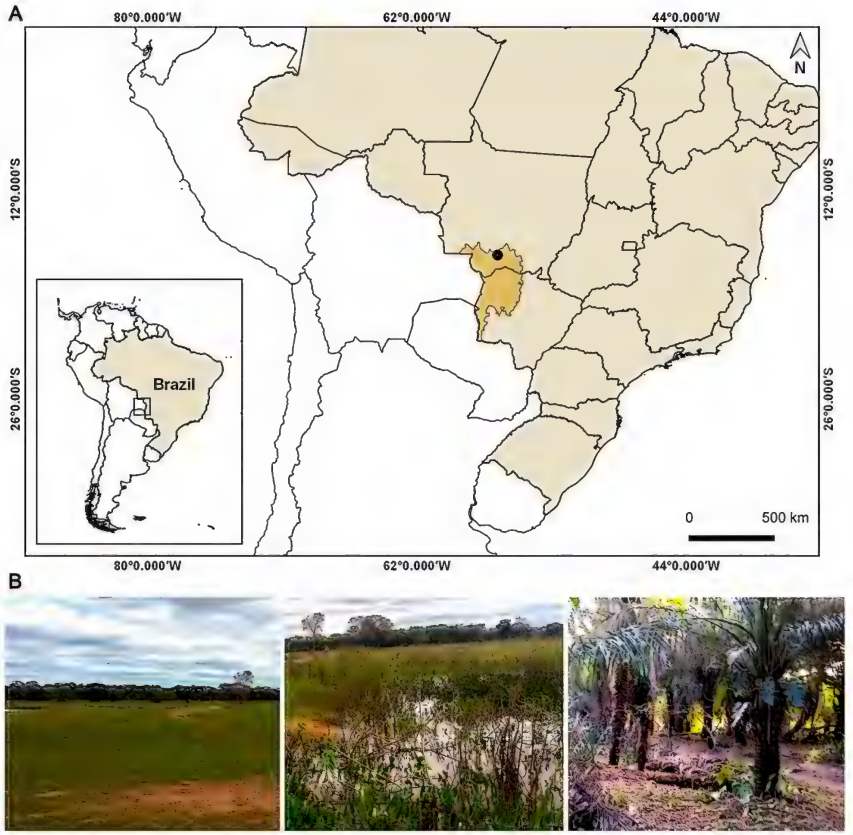

Fig. 1.A. Location of the Poconé sampling area (black dot) in South America and in the Brazilian Pantanal (yellow area). B. Some landscapes from the Poconé sampling area.

temporary, dependent upon topographical characteristics, soil composition and regulated by the climate (Rodela & Neto 2007). The vegetation comprises grass fields, forests, and aquatic plants (Prance & Schaller 1982, Ribeiro & Dias 2007).

The biome is biologically highly diverse. Its location in a region where different phytogeographic provinces (the Cerrado, Paraguayan Chaco, and Amazon and Meridional forests) converge, results in its functioning as a biogeographic corridor (PAE 2004). However, despite this rich diversity of ecosystems, most of the Pantanal biodiversity, and particularly the microbiota, is still unknown (Maia & al. 2015, Cavalcanti 2019).

Among these microorganisms, the myxomycetes (*Protozoa*: *Amoebozoa*) are prominent. These heterotrophic eukaryotes, characterized by at least two very distinct phases in their life cycle (Adamonytė & al. 2013, Eliasson 2013, Stephenson & Rojas 2017) can be found in a variety of habitats where food and humidity are available. They occur in different plant associations with different macromycetes (Andrade & al. 2006, Rufino & Cavalcanti 2007, Araújo & al. 2012).

In Brazil, myxomycete studies have been concentrated in the Northeast region, especially in the Atlantic forest and Amazon biomes (Cavalcanti 2019). Recently, those studies have been expanded to other biomes, such as the Cerrado, in the Central-West region (Xavier-Santos & al. 2016) and the Pampas, in the South region (Lima & Cavalcanti 2017). However, there is no record of myxobiota in the Pantanal. Here we present the first records of myxomycetes in this biome, as well as the first occurrence associated with *Attalea phalerata* Mart. ex Spreng. (*Arecaceae*).

Materials & methods

During July 2018, we opportunistically sampled around Km 10 of the Transpantaneira road in the municipality of Poconé, State of Mato Grosso (16°22′43″S 56°37′19″W) (Fig. 1A). The area is characterized by seasonal hydrological fluctuations and naturally open areas (Fig. 1B). The region climate is tropical hot and humid, with an average annual temperature of 25°C (Silva 2010). We identified the sampled material using micro- and macroscopic characters following a morphological species concept. We use the taxonomic nomenclature established by Lado (2019) and, follow the criteria used by Leontyev & al. (2019) for genus and family classifications. Specimen vouchers studied were deposited in the myxomycete collection of the herbarium of the Universidade Estadual de Goiás, Anápolis, Brazil (HUEG).

Results

We report six species representing *Trichiaceae* (*Arcyria obvelata, Perichaena depressa*, *P. vermicularis*) and *Physaraceae* (*Physarum album, P. compressum*, *P. polycephalum*). These species were collected over litter and living bracts of *Attalea phalerata*. This palm species—popularly known as acuri, bacuri, or uricuri—dominates the Pantanal region where it is used for food, animal forage, and construction material (Mostacedo & Fredericksen 1999, Miranda & al. 2001). The palm trees *Acrocomia intumescens* Drude (macaúba), *Copernicia prunifera* (Mill.) H.E. Moore (carnaúba), *Mauritia flexuosa* L.f. (buriti), *Orbignya phalerata* Mart. [= *Attalea speciosa* Mart.] (babaçu), and *Elaeis guineensis* Jacq. (dendezeiro) have already been recorded as important substrates for the myxobiota in Brazil (Alves & Cavalcanti 1996, Silva & al.

2010). However, this is the first Brazilian record of myxomycetes occurring on *Attalea phalerata*.

Taxonomy

Arcyria obvelata (Oeder) Onsberg, Mycologia 70(6): 1286. 1979. FIG. 2A

Sporocarps densely clustered, yellow. Stalk yellowish brown, slightly curved. Peridium persistent at base as a small shallow calyculus. Capillitia abundant, elastic, decorated with spines and half-rings. Spores yellow, 6.0–7.5 µm diam.

SUBSTRATE: Spathe (bract) of *Attalea phalerata*.

MATERIAL EXAMINED: **BRAZIL. MATO GROSSO: Poconé**, Km 10 of the Transpantaneira road, 10/VII/2018, S. Xavier-Santos 6452 (HUEG 11943); S. Xavier-Santos 6459 (HUEG 11953).

REMARKS: *Arcyria obvelata* is diagnosed by its long, cylindrical, yellow sporotheca and a capillitium only slightly connected to the epicalyx. This first record for the Central-West region establishes the species as present in all regions of Brazil. Previously reported on leaves of the *Copernicia prunifera* (Mobin & Cavalcanti 2000), this is the first record of *A. obvelata* on *Attalea phalerata* in the country.

DISTRIBUTION: Cosmopolitan (Martin & Alexopoulos 1969, GBIF 2019).

Perichaena depressa Lib., Pl. Crypt. Arduenna 4: no. 378. 1837. FIG. 2B

Sporocarp sessile, strongly flattened. Peridium double, partially iridescent, outer surface reddish brown and inner layer yellow, dehiscence circumsessile (as a lid formed from the top of the peridium and a base part as a shallow glass). Spores in mass dark yellow. Capillitia elastic, abundant, yellow, slightly warty. Spores yellow pale, minutely warty, 8.0–10.4 µm diam.

SUBSTRATE: Leaf litter.

MATERIAL EXAMINED: **BRAZIL. MATO GROSSO: Poconé**, Km 10 of the Transpantaneira road, 10/VII/2018, S. Xavier-Santos 6453 (HUEG 11954).

REMARKS: *Perichaena depressa* is easily recognized in the field due to the rapid formation of sporocarp and circumsessile dehiscence (Ukkola & Härkönen 1996). Widely distributed, it is the most frequent *Perichaena* species registered in Brazil.

DISTRIBUTION: Cosmopolitan (Martin & Alexopoulos 1969, GBIF 2019).

Perichaena vermicularis (Schwein.) Rostaf., Sluzowce Monogr., Dodatek: 34. 1876. FIG. 2C

Plasmodiocarp ring-shaped, peridium double, ochraceous yellow, dehiscence irregular, persistent at the base; inner layer membranous, papillose.

Fig. 2. Myxomycetes recorded in the Brazilian Pantanal. A. *Arcyria obvelata*; B. *Perichaena depressa*; C. *Perichaena vermicularis*; D. *Physarum album*; E. *Physarum compressum*; F. *Physarum polycephalum*. Scale bars = 0.5 mm.

Capillitia decorated with small spinules, 9.0–12.5 µm diam.

Substrate: Spathe (bract) of *Attalea phalerata*.

Material examined: **BRAZIL. Mato Grosso: Poconé**, Km 10 of the Transpantaneira road, 10/VII/2018, S. Xavier-Santos 6454 (HUEG 11945); S. Xavier-Santos 6460 (HUEG 11949).

Remarks: *Perichaena vermicularis* was previously reported in Brazil's Northeast and Southeast regions plus one record from the Midwest area. This is the first Brazilian record of the species occurring on *Attalea phalerata*.

Distribution: Cosmopolitan (Martin & Alexopoulos 1969, GBIF 2019).

Physarum album (Bull.) Chevall., Fl. Gén. Env. Paris 1: 336. 1826. Fig. 2D

Sporocarps grouped. Peridium covered by calcareous granules, grayish white, petaloid dehiscence. Stalk, blackish brown base, curved. Spores in dark brown mass. Capillitia hyaline, interconnected by fusiform white calcareous granules. Spores violet brown, moderately warty, 8.0–9.5 µm diam.

Substrate: Spathe (bract) of *Attalea phalerata*.

Material examined: **BRAZIL. Mato Grosso: Poconé**, Km 10 of the Transpantaneira road, 10/VII/2018, S. Xavier-Santos 6455 (HUEG 11942); S. Xavier-Santos 6461 (HUEG 11951).

Remarks: Key characters of *Physarum album* are its pendant sporocarp and blackish brown pedicel that becomes white near the apex. This species has already been found on leaves of *Elaeis guineensis* (Silva & al. 2010); this is the first Brazilian record on *Attalea phalerata*.

Distribution: Cosmopolitan (Martin & Alexopoulos 1969, GBIF 2019).

Physarum compressum Alb. & Schwein., Consp. Fung. Lusat.: 97. 1805. Fig. 2E

Sporotheca with rounded lobes. Stalk short, dark brown (almost black). Capillitia with irregular nodules. Spores dark, 9.0-13.5 µm diam.

Substrate: Spathe (bract) of *Attalea phalerata*.

Material examined: **BRAZIL. Mato Grosso: Poconé**, Km 10 of the Transpantaneira road, 10/VII/2018, S. Xavier-Santos 6456 (HUEG 11946); S. Xavier-Santos 6462 (HUEG 11952).

Remarks: *Physarum compressum* is characterized by its fan-shaped or flabelliform sporotheca that dehisce by an apical or irregular cleft and the presence of calcium granules after opening. This is the first record for the Central-West region. This species has already been found on leaves of *Elaeis guineensis* (Silva & al. 2010); but this is the first Brazilian record on *Attalea phalerata*.

Distribution: Cosmopolitan (Martin & Alexopoulos 1969, GBIF 2019).

Physarum polycephalum Schwein.,
Schriften Naturf. Ges. Leipzig 1: 63. 1822. FIG. 2F

Sporocarps grouped. Sporotheca multilobed, compressed, umbilicate in the bottom, peridium simple, gray in the center and yellow on the border. Stalk long, brownish yellow. Spore mass dark brown. Capillitia dense, pale yellow, intertwined by pale yellow calcareous nodules. Spores globose, violaceous-brown, spinulose 7.0–9.0 µm diam.

SUBSTRATE: Spathe (bract) of *Attalea phalerata.*

MATERIAL EXAMINED: **BRAZIL. MATO GROSSO: Poconé**, Transpantaneira road, Pousada Piuval, 10/VII/2018, S. Xavier-Santos 6457 (HUEG 11948).

REMARKS: One prominent macroscopic character of *Physarum polycephalum* is its multilobed and compressed sporotheca that vary in color between yellow, gray, and bronze. This species is widely used as a biological model, due to its easy growth and manipulation in vitro, the rapid response of the plasmodium, migratory behavior, and attraction for food and humidity, among other factors (Adamatzky 2010, Bozzone 2011). This is the first Brazilian report of its occurrence on *Attalea phalerata.*

DISTRIBUTION: Pantropical and Northern temperate zone (Martin & Alexopoulos 1969, Lado & Basanta 2008, Ndiritu & al. 2009, GBIF 2019).

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The authors thank Dr. Carlos Rojas Alvarado (University of Costa Rica, Costa Rica) and Ricardo Enrique Morales Hernandez (Facultad Multidisciplinaria de Occidente, Universidad de El Salvador) for reviewing the manuscript; Dr. Shaun Pennycook for nomenclatural review and Dr. Lorelei L. Norvell for editorial review; and the Fundação de Amparo à Pesquisa do Estado de Goiás (FAPEG) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for a scholarship granted to Izabel Cristina Moreira (FAPEG/Master's), Lucas Leonardo da Silva (CNPq/Herbário Virtual da Flora e dos Fungos/AT), and Antônio Sérgio Ferreira de Sá (CNPq/IC).

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Spathularia nigripes and *Trichoglossum walteri* newly recorded from Turkey

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Abstract—Two ascomycetous species, *Spathularia nigripes (Cudoniaceae)* and *Trichoglossum walteri (Geoglossaceae),* are reported as new records for the Turkish mycobiota, based on collections from İstanbul and Konya provinces. Descriptions of the newly recorded species are accompanied by color photographs illustrating their macroscopic and microscopic features.

Key words—biodiversity, earth tongue, new record, taxonomy

Introduction

Ascomycetous macrofungi producing large pileate tongue-shaped fruiting bodies within several genera are generally referred to as earth-tongues. They are widely distributed and grow on various substrates. *Spathularia* Pers. and *Trichoglossum* Boud. are among these genera.

Spathularia (*Cudoniaceae*) is represented by 12 species (Kirk & al. 2008) that are generally characterized by fleshy, spathulate and stipitate ascocarps, clavate asci, filiform paraphyses, one-celled to septate ascospores; some species also produce obovoid to subgloboid conidia.

Trichoglossum (*Geoglossaceae)* is generally characterized by club-shaped brownish black apothecia, smooth or velvety stipes, 4–8-spored inoperculate asci with amyloid apical pores, apically curved or coiled septate paraphyses, and multiply septate ascospores.

Seven geoglossoid or cudonioid fungi taxa have been recorded from Turkey: *Cudonia circinans* (Pers.) Fr., *Geoglossum lineare* Hakelier, *G. umbratile* Sacc.,

Trichoglossum hirsutum (Pers.) Boud., *T. variabile* (E.J. Durand) Nannf., *Spathularia flavida* Pers. and *Spathulariopsis velutipes* (Cooke & Farl.) Maas Geest. (Akata & Kaya 2013; Güngör & al. 2015a,b), but the current checklists (Sesli & Denchev 2014, Solak & al. 2015) and the most recent Turkish mycobiota (Kaya & al. 2016; Işık & Türkekul 2018; Kaya & Uzun 2018; Sesli & al. 2018; Sadullahoğlu & Demirel 2018; Uzun & al. 2018; Acar & al. 2019; Akçay 2019; Keleş 2019; Uzun & Kaya 2019a,b) do not cite *Spathularia nigripes* and *Trichoglossum walteri* from the country. This work contributes new records to the mycobiota of Turkey.

Materials & methods

During 2017–2018, ascocarps were collected from Ereğli district (Konya province) and Şile district (İstanbul province). Observations on the morphology and ecology were noted in the field and the fruitbodies were photographed in their natural habitats prior to transfer to the laboratory for further research. Tissues were mounted in Congo Red and Melzer's reagent and examined under a Nikon Eclipse Ci-S trinocular light microscope. The samples were identified with the help of the relevant literature (Mains 1954, Geesteranus 1965, Cacialli & al. 1992, Vidal 1994, Fernández Vicente & Undagoitia 2004, Sandras & Hairaud 2007, Bessette & al. 2007, Placido Iglesias 2007, Requejo 2010, Ribes & al. 2015). IndexFungorum (2019) was followed for the systematics of the taxa. The specimens are kept at Karamanoğlu Mehmetbey University, Kamil Özdağ Science Faculty, Department of Biology, Turkey (KMU).

Taxonomy

Spathularia nigripes (Quél.) Sacc. Syll. Fung. 8: 49 (1889) Fig. 1

Apothecia ≤32 × 7 mm, spathulate to claviform, composed of a fertile head and a stipe. The fertile head 6.5–11.5 × 4–7 mm, ellipsoid, ovoid, somewhat squashed or flattened, longitudinally furrowed, sometimes wavy, glabrous, dirty white to beige. Stipe 7–20.5 × 2.5–3.7 mm, cylindrical, slightly thickened at the base, smooth or slightly furfuraceous, dark grey to brownish-grey or bluish-grey. Excipular cells have a prismatic texture in both fertile head and stipe. Asci 101–135 × 9–13 (14.5) µm, claviform, inoperculate, inamyloid, generally 8-spored, arising from croziers. Paraphyses filiform, hyaline, septate, with curved, twisted, or spiral apex, some bifurcated near the apex. Ascospores 38–42 × 2–2.6 µm, needle-shaped, hyaline, smooth, some septate, with small, scattered drops, heteropolar, acute at one end while obtuse at the other. Secondary spores (conidia) originating from mature ejected ascospores, 2.2–2.4 × 2–2.2 µm, subglobose and attached to the ascospores by a thin sterigma.

Fig 1. *Spathularia nigripes* (KMU–Uzun 6290): a. ascocarps; b. asci and paraphyses (Congo red); c. ascospores (Melzer); d. secondary spores (conidia) developing from ascospores (Congo red). Scale bars = 10 µm.

Specimen examined—**TURKEY, Istanbul: Şile,** Sofular Village, 41°09′N 29°30′E, 105 m, broad leaved forest, on decaying stump of *Laurus nobilis* L. (*Lauraceae*), 07.03.2018, Y. Uzun 6290 (KMU).

Comments—The Turkish collection of *Spathularia nigripes* matches literature descriptions. *Spathularia* species generally resemble each other. *Spathularia flavida* is separated from *S. nigripes* by its larger (≤80 mm) carpophores and flattened, compressed or lobed fertile zone (Breitenbach and Kränzlin 1984, Cacialli & al. 1992). The longer ascospores of *S. flavida* (≤70 µm) are another distinguishing character (Ribes & al. 2015).

Fig 1. *Trichoglossum walteri* (KMU–Uzun 6019): a,b. ascocarps; c. hairs; d. asci, paraphyses and ascospores; e,f. ascospores (all in Melzer). Scale bars = 20 µm.

Spathularia nigripes is known to occur on small remnants of unidentified wood in mixed forest of *Pinus canariensis* C. Sm. and *Eucalyptus,* and in fayal-heath (*Erica* L., *Ilex* L., *Laurus* and *Myrica* L. spp.) in Spain (Ribes & al. 2015), among *Erica arborea* L. wood remnants in Greece (Mycohellas 2019) and on sandy soil among woody debris in mixed forest in Italy (Cacialli & al. 1992).

Trichoglossum walteri (Berk.) E.J. Durand, Ann. Mycol. 6: 440 (1908) Fig. 2

Ascocarps 30–80 mm long and 5–7 mm thick, spathulate to ligulate, with a median groove and obtuse apex, black to brownish black, densely setose. Stipe 3–6 mm thick, setose, concolorous with the ascogenous portion. Asci 150–220 × 14–19 µm, cylindrical to somewhat clavate, 8-spored, apical pore becoming blue in Melzer's solution. Paraphyses septate, generally curved and thickened at the apex ≤8 µm. Ascospores (70–)80–110(–120) × 5–6.5 µm, subcylindrical to fusiform, narrower below, generally with 7–8 septa, some 4-septate or aseptate when immature, brown to blackish brown. Hymenial setae 90–130 × 6–9 µm, thick-walled, straight, not forked, dark-brown to black-brown.

Specimen examined—**TURKEY, Konya: Ereğli,** Taşağıl Village, 37°30′N 33°5′E, 1015 m, on soil under *Salix* and *Populus* near a puddle, 09.12.2017, Y. Uzun 6019 (KMU).

Comments—*Trichoglossum walteri* is morphologically similar to *T. hirsutum, T. octopartitum* Mains, and *T. variabile.* The ascospores of *T. hirsutum* and *T. variabile* are slightly longer and have more septa (9–15). The spores of *Trichoglossum octopartitum* are, like those of *T. walteri,* 7-septate but longer (101–125(–138) (Kučera & al. 2010).

Mains (1954) reports *T. walteri* on soil and rotting wood in North America, while Placido Iglesias (2007) collected it in wet mossy soil areas in Spain.

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Clitocybula azurea in Argentina: redescription and phylogenetic position

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Abstract—*Clitocybula azurea,* which was described by Singer in 1973 from Brazil and Venezuela, is characterized by its bluish to grayish blue tinges, narrow lamellae, cespitose and lignicolous habit, and small, amyloid, subglobose basidiospores. However, despite its striking coloration, the species is not described or illustrated in recent literature. The species is here redescribed and illustrated, its distribution extended to Argentina, and its phylogenetic position analysed.

Key words—*Agaricales*, Atlantic forest, ITS, *Marasmiaceae*, mushroom, taxonomy

Introduction

Clitocybula Métrod is a phylogenetically well-defined genus, related to other genera of the hydropoid clade (Matheny & al. 2006), also including *Megacollybia* Kotl. & Pouzar, *Hydropus* Kühner ex Singer, *Trogia* Fr., *Gerronema* Singer, *Porotheleum* Fr., *Leucoinocybe* Singer ex Antonín & al., and *Lignomphalia* Antonín & al. (Antonín & al. 2019). It is a small genus, with c. 15 species (Antonín & al. 2019), with a wide morphological diversity and exhibiting small clitocyboid, omphalioid, collybioid, mycenoid or pleurotoid habits (Singer 1962, Bigelow 1973, Antonín & al. 2019). Barrasa & al. (2006)

defined *Clitocybula* based on five main characteristics: the radially fibrillose to squamulose pileus surface; the absence of a cellular hypoderm and pleurocystidia [except for their occasional presence as in *C. azurea* (Singer 1962)]; the presence of cheilocystidia and dermatocystidia; amyloid smooth basidiospores; and lignicolous habit. *Clitocybula* is restricted to the temperate regions of both hemispheres (Singer 1986, Latha & al. 2015), plus several tropical-subtropical species, e.g., *C. azurea* and *C. cyanocephala* (Pat.) Singer from the neotropics (Singer 1973), *C. omphaliiformis* Pegler from Africa (Pegler 1977), *C. canariensis* Barrasa & al. from Canary Islands (Barrasa & al. 2006), and *C. sulcata* K.N.A. Raj & Manim. from India (Latha & al. 2015).

Because of the absence of the recent description and illustration in the literature, the aim of this work is to re-describe and illustrate *Clitocybula azurea* based on new collections, expand its distribution area, and analyze its phylogenetic position.

Materials & methods

Morphological studies

The specimens were collected in Misiones province, Argentina, and they were photographed and described macroscopically in situ, and then analyzed morphologically and identified following the criteria and terminology proposed by Vellinga (1988) and Lodge & al. (2004). The color terminology follows Kornerup & Wanscher (1978). Tissues were cut by hand and mounted in a solution of 5% KOH (v/w) with 1% floxin aqueous solution for microscopical examination. Melzer's reagent (Wright & Albertó 2002) was used to verify amyloid reaction. The microscopic structures were measured directly with 1000× immersion objective or through photographs taken with a Leica EC3 built-in camera using ImageJ software (Schneider & al. 2012). The notation L = refers to the number of true lamellae (ranging from the stipe insertion to the margin of pileus) counted at the pileus margin. The minimum-maximum intervals were provided for the different microscopic structures. For basidiospores, n = indicates the number of basidiospores measured, x = the average value, Q = length:width ratio, and Qx = mean value of Q. Nomenclatural authorities follow Index Fungorum (2020); herbarium acronyms follow Thiers (2020). The collected specimens were dried, frozen for a week, and conserved in the Herbarium, Instituto de Botánica del Nordeste, Corrientes, Argentina (CTES).

DNA extraction, amplification, and sequencing

DNA isolation from small parts of fungal tissue, polymerase chain reaction (PCR) amplification, and sequencing of PCR products were performed through the Barcode of life Project following protocols in Ivanova & al. (2008) and Ivanova & Grainger (2006). The nuclear ribosomal internal transcribed spacer region (ITS) was amplified using the basidiomycete specific primer set: ITS1-F (CTTGGTCATTTAGAGGAAGTAA)

TABLE 1: Sequences of species of *Clitocybula* and related genera, with *Baeospora myosura* as outgroup, used in the phylogenetic analyses. Sequences obtained in this study are in **bold.**

SPECIES	SPECIMEN VOUCHER	ORIGIN	ITS	REFERENCE
Baeospora myosura	AFTOL-ID 1799	USA	DQ484063	Matheny & al. 2006
C. atrialba	AFTOL-ID 1529	USA	DQ192179	Curtis & al. unpubl.
C. azurea	**Alberti ADA015-17**	**Argentina**	**MT009482**	**This work**
	Niveiro 3173	**Argentina**	**MT009483**	**This work**
C. familia	BRNM 736053	Czechia	JF730328	Antonín & al. 2011
	X21	Czechia	LN714532	Větrovský & al. 2016
C. aff. *lacerata*	GRSM77072	USA	FJ596916	Hughes & al. 2009
C. lacerata	PRM:951559 (Neotype)	Czechia	MK713541	Antonín & al. 2019
	LE6639	Russia	HM191746	Malysheva & al. 2011
	LE262744	Russia	HM191747	Malysheva & al. 2011
	16837	USA	JF908760	Garbelotto & al. unpubl.
C. oculus	PRM 934963	USA	LT854020	Antonín & al. 2019
	BIOUG24046-E05	Canada	KT695404	Telfer & al. 2015
	3512	Canada	KM406971	Berube & al. unpubl.
	BIOUG24046-B03	Canada	KT695321	Telfer & al. 2015
	LIP (Moreau CAN 13-50)	Canada	LT854017	Antonín & al. 2019
	PBM 1156 (WTU)	USA	DQ192178	Curtis & al. unpubl.
Clitocybula sp.	TENN60306/TFB12058	USA	EU623637	Hughes & al. 2007
Lignomphalia lignicola (as *C. lignicola*)	LE262727	Russia	HM191731	Malysheva & al. 2011, Antonín & al. 2019
	LE6625	Russia	HM191732	Malysheva & al. 2011, Antonín & al. 2019
Leucoinocybe taniae (as *C. flavoaurantia*)	D	Italy	HM191743	Malysheva & al. 2011, Antonín & al. 2019
	GDOR (Type)	Italy	HM191744	Malysheva & al. 2011, Antonín & al. 2019
Megacollybia marginata	LE 202274	Russia	EU623688	Hughes & al. 2007
	HR 90203	Czechia	LT854047	Antonín & al. 2019
M. clitocyboidea	TENN062231 (Type)	Japan	NR119690	Hughes & al. 2007
	HMJAU4024/TENN62230	China	EU623670	Hughes & al. 2007
Trogia infundibuliformis	KUN HKAS56709	China	JQ031776	Yang & al. 2012
	KUN HKAS63661	China	JQ031775	Yang & al. 2012
T. venenata	KUN HKAS54710	China	JQ031772	Yang & al. 2012
	KUN HKAS56679	China	JQ031773	Yang & al. 2012

and ITS4-B (CAGGAGACTTGTACACGGTCCAG) (Gardes & Bruns 1993). The PCR products were sequenced in the Canadian Centre for DNA Barcoding (CCDB), Canada.

Molecular phylogeny

The dataset was compiled using our data (MT009482, MT009483) and 28 sequences selected from GenBank based on BLAST results and previous works (Malysheva & al. 2011, Antonín & al. 2019); *Baeospora myosura* (Fr.) Singer was selected as outgroup (Table 1). Sequence editing was done in BioEdit 7.2.5 (Hall 1999). Sequences were aligned by MAFFT 7 (Katoh & Standley 2013) under the Q-INS-i criteria. When necessary, the alignment was manually adjusted with MEGA 5 (Tamura & al. 2011). Potential ambiguously aligned segments of ITS1-ITS2 were detected by Gblocks 0.91b (Castresana 2000).

Phylogenetic reconstruction was inferred using Maximum Likelihood (ML) and Bayesian Inference (BI) separately. Maximum Likelihood was carried out in RaxML-HPC v.8 (Stamatakis 2014), searching for the best scored trees with GTRGAMMA model for the entire dataset with all the default parameters estimated by the software. The analysis first involved 100 ML searches, each starting from one randomized stepwise addition parsimonious tree. Only the best scored ML tree was kept, and the confidence of nodes was accessed through Rapid bootstrapping (BS).

Bayesian Inference (BI) was performed in MrBayes 3.2.6 (Ronquist & al. 2012). The evolutionary models for BI were estimated using the Akaike Information Criterion (AIC), as implemented in jModelTest2 v.1.6. (Guindon & Gascuel 2003, Darriba & al. 2012), and implemented with two independent runs, each beginning from random trees with four simultaneous independent chains. A total of 2×10^7 generations were carried out, sampling one tree every 1×10^3 generations.

Only the BI tree is shown, indicating support values (BPP/BS) at each node. A node was considered to be strongly supported if it showed a BPP ≥0.95 and/or BS ≥90%, while moderate support was considered BPP ≥0.70 and/or BS ≥70%.

Results

Phylogenetic analysis

The original dataset comprised 30 taxa and 1562 positions. The Gblocks curated dataset comprised 540 positions, of which 320 were constant, 220 variable, and 183 parsimony informative. The best substitution model was estimated as: TPM3uf+G. The resulting BI tree agreed with the ML analysis. Five well-defined clades were recovered from all analyses: *Leucoinocybe* (1/100), *Lignomphalia* (1/100), *Megacollybia* (1/100), *Trogia* (0.77/–), and *Clitocybula* (0.98/70). *Baeospora myosura* was used as outgroup. *Clitocybula azurea* sequences grouped closely with *C. familia* (0.78/–). The *Clitocybula* clade includes a second subclade formed by *C. lacerata* and *C. oculus* (Fig. 1).

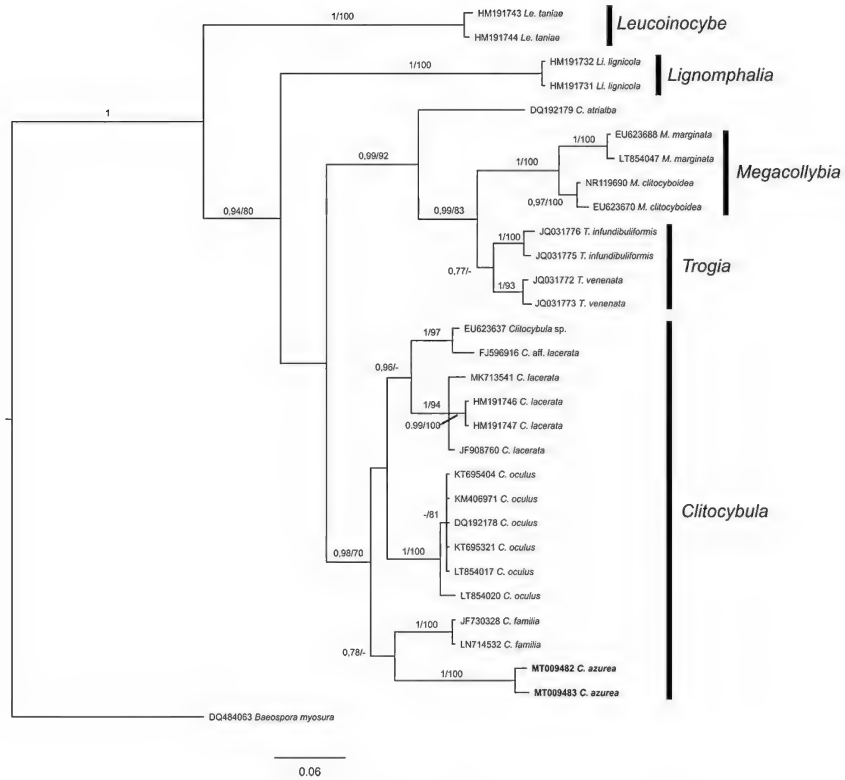

FIG. 1: Molecular phylogeny of species of *Clitocybula* and related genera, with *Baeospora myosura* as outgroup, carried out by Bayesian Inference based on dataset of ITS sequences. Bayesian posterior probabilities BPP ≥0.7, and Bootstrap values BS ≥70% are shown.

Taxonomy

Clitocybula azurea Singer, Beihefte zur Sydowia 7: 18 (1973). FIGS 2–4

BASIDIOMATA gregarious, in small clusters or densely cespitose, xylophagous. PILEUS ≤20 mm broad, plano-convex to convex with undulate margin when young, then broadly conical, finally convex with acute papilla; thin and delicate, distinctly hygrophanous, dark blue (22F5-8) when young, then dark turquoise (24F6-8) to dark green (26F5-8), striate with greyish (23A2 "bluish white", to 26A2 "greenish white") lines radiating from the pileus center, finally white with a slight greenish hue, greyish turquoise (24D5) to greyish green (26D5) on the disc to completely white (1A1) to greenish-white (25A2) towards margin, dry, innately fibrillose; margin

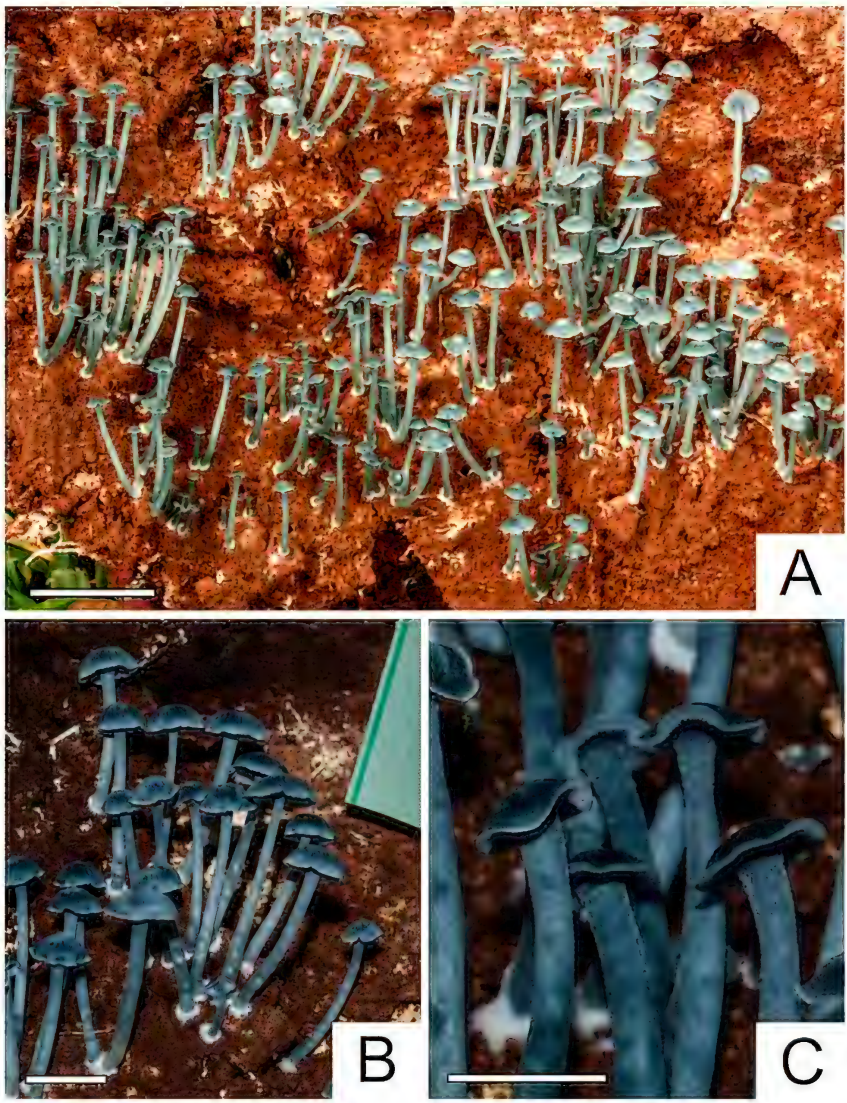

Fig. 2: *Clitocybula azurea* (Alberti ADA015-17), young specimens. A. General aspect; B. Habit and basidioma detail; C. Pileus and stipe surface detail. Scale bars: A = 10 cm; B, C = 1 cm.

straight to wavy. Context thin, concolorous with the pileus surface, odor and taste indistinct. Lamellae subfree to adnate, very narrow (<0.5 mm), crowded to close (2–3 L/mm), dark blue when young, turning whitish,

Fig. 3: *Clitocybula azurea*, mature specimens. A, B. General aspect, habit, and detail of whitish basidioma (Niveiro 3165); C. Basidioma detail of an intermediate state (Niveiro 3134). Scale bars: A = 10 cm; B, C = 1 cm.

with even concolorous edge; with two ranks of lamellulae. Stipe central, 10–40(–60) × 3–8 mm, cylindrical, equal or slightly narrowing towards the apex, hollow, surface concolorous with the pileus surface, fibrillose, dry,

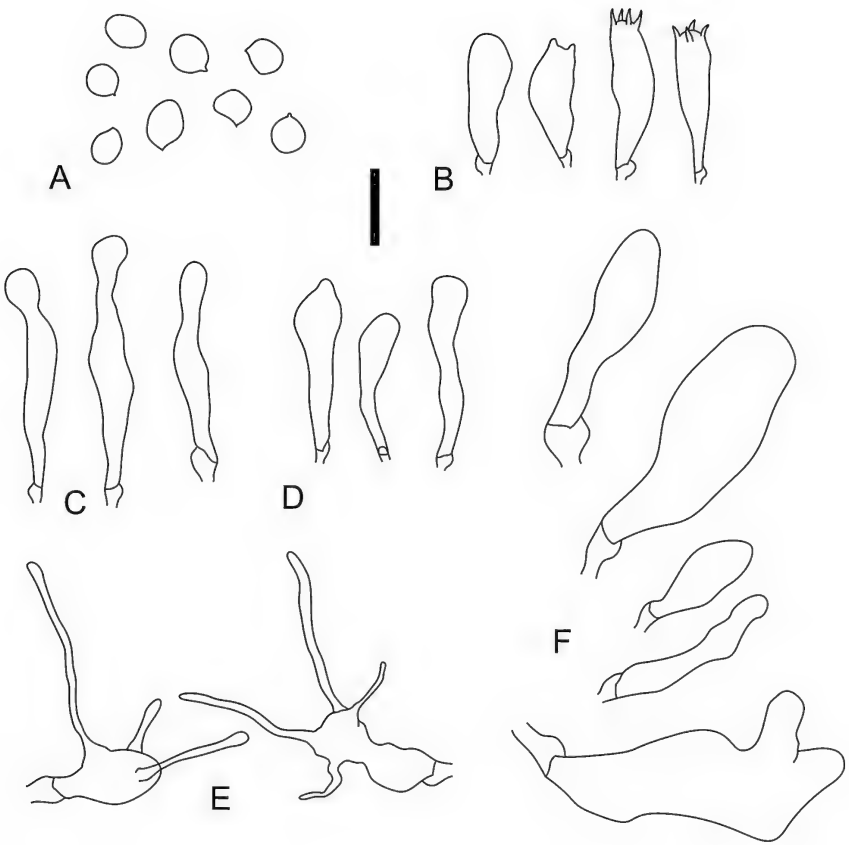

Fig. 4: *Clitocybula azurea* (Niveiro 3165). A. Basidiospores; B. Basidia and basidioles; C. Cheilocystidia; D. Pleurocystidia; E. Pileocystidia; F. Caulocystidia. Scale bar = 10 µm.

with a white (1A1) basal mycelial patch. Annulus absent. Spore-print not observed, presumably white.

Basidiospores 4–6.5 × 3–5 µm, x = 5.2 × 4.2 µm, Q = 1.04–1.44, Qx = 1.23, n = 25; subglobose in frontal view, broadly ellipsoid in side-view, with ventral side plane, without a suprahilar depression, amyloid, hyaline, smooth, thin-walled. Basidia 16–23(–28) × 4–6 µm, clavate, 4-spored, hyaline, thin-walled. Basidioles 15–20 × 4–8 µm, clavate, thin-walled. Cheilocystidia and pleurocystidia 18–30 × 3.5–8 µm, versiform, cylindrical, clavate, utriform, with apical papilla or subcapitate, scattered and inconspicuous in young specimens, more visible in mature specimens. Hymenophoral trama subregular; hyphae 2.5–6 µm diam, thin-walled, inamyloid. Pileipellis

a cutis made up of prostrate, more or less parallel hyphae; hyphae 2.5–7 µm diam, smooth, inamyloid, thin-walled, with pileocystidia as terminal elements. Pileocystidia broadly clavate to subglobose, 7–10 × 5–8 µm, with 3-5 filamentous excrescences of 12–22 × 1.5–2.5 µm. Stipitipellis a cutis made up of smooth, 3–6 µm diam hyphae. Caulocystidia 27–39.5(–47) × 6.5–14 µm, cylindrical to clavate, occasionally with 2–3 lobes at the apex, either concentrated in scattered fascicles or scattered and solitary, the latter in general cylindrical and smaller (27–33 × 6.5–9 µm) than those grouped in fascicles. Clamp connections present.

Ecology—Growing on decaying wood, logs, and stumps of gymnosperms and angiosperms. Caespitose, forming groups of numerous (c. 10) to very abundant (60–90) basidiomes.

Distribution—Known from Brazil (São Paulo State, type locality) and Venezuela (Bolivar State) (Singer 1973); Jamaica and Costa Rica (GBIF 2020); and Argentina (Misiones Province).

Specimens examined—**ARGENTINA**, **Misiones**: **Gral. Belgrano**, San Antonio, Campo Anexo Manuel Belgrano (CAMB-INTA) 26°02′12″S 53°47′23″W, 822 m a.s.l., in forestation of *Araucaria angustifolia* (Bertol.) Kuntze, with understory of *Alsophila setosa* Kaulf., 23/03/2017, leg. Niveiro 3159 (CTES); leg. Niveiro 3165 (CTES); leg. Niveiro 3173 (CTES: GenBank MT009483); leg. Alberti ADA015-17 (CTES; GenBank MT009482); in forestation of *Araucaria angustifolia* behind CAMB, 26°03′08″S 53°46′14″W, 23/03/2017, leg. N. Niveiro 3134 (CTES).

Comments—*Clitocybula azurea* is characterized by its bluish to grayish blue tinges, the narrow lamellae, the cespitose and lignicolous habit, and the small, amyloid, subglobose basidiospores. Only two *Clitocybula* species with bluish coloration are known: *C. cyanocephala* and *C. azurea*, both known from the neotropics (Singer 1979). *Clitocybula cyanocephala* differs by its broad lamellae and larger basidiospores (5.5–6.5 × 4.5–5 µm) (Singer 1979). The Argentinean *C. azurea* specimens have slightly larger basidiospores (4–6.5 × 3–5 µm) than those described by Singer (1979) (3–4.5 µm broad), making the delimitation between both species more difficult due to the partial overlapping spore ranges. However, the character of the lamellae (narrow and crowded to close in *C. azurea* vs. broad and subclose to medium distant in *C. cyanocephala*) is enough to distinguish the two species.

Pegler (1983), recombined *Clitocybula cyanocephala* as *Calocybe cyanocephala* (Pat.) Pegler, because he did not observe amyloid basidiospores in either the type material or new specimens from the Lesser Antilles.

Another *Clitocybula* species that resembles *C. azurea* in its caespitose and mycenoid habit is *C. familia* (Peck) Singer, which differs by its beige-brown

pileus with an olivaceous grey tinge (and lacking grayish blue tinges) when fresh (Antonín & al. 2011).

Microscopically similar species are *C. abundans* (Peck) Singer and *C. oculus* (Peck) Singer, with morphologically similar basidiospores, cheilocystidia, and caulocystidia (Bigelow 1973, Antonín & al. 2011, 2019). However, these species are easily separated by their macroscopic characters: *C. abundans* has a whitish pileus, often with a darker to fuscous center (Bigelow 1973, Antonín & al. 2019), and in addition to a similar coloration to *C. abundans, C. oculus* has a squamulose stipe (Bigelow 1973).

Mycena interrupta (Berk.) Sacc. [= *M. cyanocephala* Singer] is a bluish species know from the temperate region of southern hemisphere (Singer 1969, Horak 1983, Gates & Ratkowsky 2014) that macroscopically resembles *C. azurea* differs in its larger basidiospores (9–12 × 6–8 μm), diverticulate cheilocystidia, and pseudoamyloid trama (Horak 1980).

Discussion

Clitocybula is a small genus with a wide morphological diversity and is phylogenetically well-defined. Our study, as well as those by Malysheva & al. (2011) and Antonín & al. (2019), indicates that *Clitocybula* s.l. should be divided into more genera such as *Lignomphalia* and *Leucoinocybe*. The addition of the Argentinean *C. azurea* specimens reinforces *Clitocybula* as a well-defined genus.

Within *Clitocybula*, Antonín & al. (2019) showed that *C. familia* is related to *C. oculus* and *C. lacerata* (Scop.) Métrod as another related clade. However, adding *C. azurea* to the analysis divides these four species into two main clades: *Clitocybula azurea* with *C. familia*, moderately supported (BPP = 0.78); and *C. oculus* with *C. lacerata*, unsupported (Fig. 1). Further analyses are necessary (including species not yet sequenced), to fully resolve the relationships among these species. Unfortunately, there are no available sequences of the other bluish, morphologically similar species, *C. cyanocephala* to confirm whether these are related to each other or even to all other mycenoid *Clitocybula* species.

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Gerronema nemorale: first report of the genus and species from Pakistan

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Abstract—Basidiomata of a *Gerronema* species, collected in Murree, Punjab, Pakistan, have been confirmed as *G. nemorale* by morphological and ITS1-5.8S-ITS2 rDNA sequence analyses. This is the first report of the genus *Gerronema* from Pakistan, and the first record of *G. nemorale* for the South Asian region.

Key words—*Agaricales*, *Agaricomycetes*, *Basidiomycota*, lignicolous agarics, sarcodimitic

Introduction

Gerronema Singer (*Agaricales*, *Basidiomycota*) was created by Singer (1951) to accommodate three omphalinoid–clitocyboid species from South America. The addition of several additional species (Singer 1961, 1964, 1975, 1986) caused it to be regarded as heterogeneous by many other authors. Molecular phylogenetic analysis by Lutzoni (1997) using combined nrITS and nrLSU datasets suggested that *Gerronema* was polyphyletic. Redhead (1986) restricted *Gerronema* to species with sarcodimitic tissues; including the type, *G. melanomphax* Singer. Norvell & al. (1994) limited *Gerronema* to species with a lignicolous habitat, thin-walled basidiospores, and sarcodimitic tissues. *Gerronema* in this restricted sense is monophyletic and falls in the /hydropoid clade (Moncalvo & al. 2002; Antonín & al. 2008).

Gerronema as recently accepted is a genus of small- to medium-sized white-spored lignicolous agarics with decurrent gills, inamyloid thin-walled basidiospores, and sarcodimitic tissues (Norvell & al. 1994). The genus has a

primarily tropical distribution but is also found in Europe and eastern North America where it produces basidiomata during hot, muggy summer weather (Norvell & al. 1994; Redhead & al. 2002). The genus is represented by 125 species worldwide (www.speciesfungorum.org, accessed on 27 December 2020).

During a routine macrofungal survey, specimens were found which resembled *Gerronema*. Detailed morphological and ITS sequence analyses were performed to identify the specimens to species.

Material & methods

Sampling site

Murree, an important Himalayan hill station (33.35°N 73.27°E, 2290 m asl) lies 50 km northeast of Islamabad (the capital of Pakistan) in the Himalayan foothills (murreehill.com/introduction.html). The subtropical monsoon climate has an annual precipitation of c. 1800 mm, with the maximum precipitation occurring in July and August (World Weather Information Service 2020).

Pinus roxburghii Sarg. dominates the forest regions near Murree, with *P. wallichiana* A.B. Jacks. found at the higher elevations. *Abies pindrow* (Royle ex D. Don) Royle, *Cedrus deodara* (Roxb. ex D. Don) G. Don, and *Picea smithiana* (Wall.) Boiss., are scattered sparingly throughout the Murree forests (Hameed & al. 2012). *Aesculus indica* (Wall. ex Cambess.) Hook., *Quercus dilatata* Royle, and *Q. oblongata* D. Don [= *Q. incana* Roxb.] are among the deciduous broadleaf trees in the upper regions (Beg 1975). Shrubby species like *Carissa opaca* Stapf ex Haines, *Dodonaea viscosa* (L.) Jacq., *Justicia adhatoda* L., and *Myrsine africana* L., are also present (Hussain & Illahi 1991).

The soils are classified as Entisols and Inceptisols, with more acid soils predominating above 2000 m. The soils are typically loamy and shallow, and their development has been restricted due to the steepness of the slopes (Soil Survey of Pakistan 1987).

Collection & morphological characterization

Basidiomata were collected, tagged, photographed, and characterized morphologically. Colors were designated following the Munsell Soil Color Charts (1994). The specimens were hot-air dried for preservation. Microscopic features, measurements, and drawings were made from tissues rehydrated and crush-mounted in 5% KOH and stained with Congo red (1% aqueous) or in Melzer's reagent. Basidiospores, basidia, cystidia, and pileal and stipitipellis elements were examined with an Olympus CH 30RF 200 compound microscope equipped with a digital camera; measurements were recorded using ScopeImage 9.0(x5) version 1.00. For basidiospores, numbers follow the formula [n/m/p] = n basidiospores, m specimens, p collections. Basidiospore dimensions follow (a–)b–c(–d), where b–c contains at least 90% of the measured values with extreme values given in

parentheses. The average length and width of basidiospores is represented by avl and avw. Quotient Q is used to symbolize the length/width ratio of individual spores; avQ represents the Q average of all basidiospores. The examined collections were deposited in the herbarium of the Department of Botany, University of the Punjab, Lahore, Pakistan (LAH).

DNA extraction and PCR amplification

Genomic DNA was extracted from 30–50 mg of dried basidioma in a 2% CTAB extraction buffer, following the Bruns (1995) protocol with some modifications. The nrDNA ITS region was amplified using ITS1F (forward) and ITS4 (reverse) primers (White & al. 1990). The polymerase chain reaction (PCR) was performed with the Extract-N-Amp PCR kit in 20 µl reaction volumes according to Gardes & Bruns (1993). The size of the PCR product was determined on a 1% agarose gel in a gel documentation system (UVtec, Cambridge, UK) using default settings. The PCR products were directly sequenced by the Beijing Genomics Institute in both directions using the same pair of amplification primers. The newly generated sequences were deposited in GenBank.

Sequence alignment, dataset assembly, and phylogenetic analysis

Newly generated *Gerronema* ITS sequences, along with those retrieved in a GenBank BLAST search were used for the phylogenetic analysis. The ITS sequence dataset comprised the Pakistani sequences, those of other *Gerronema* species selected based on their similarity indices, and other taxa that were used in previous phylogenetic analyses (Cooper 2014; Antonín & al. 2008; Latha & al. 2018). *Multiclavula corynoides* (Peck) R.H. Petersen and *M. vernalis* (Schwein.) R.H. Petersen were selected as outgroup, following Antonín & al. (2008).

The dataset was aligned using MAFFT (Katoh & Standley 2013). DNA sequences were trimmed with the conserved motifs 5'-(...GAT)CATTA- and -GACCT(CAAA...)-3' with the program BioEdit sequence alignment editor v.7.2.5.0 (Alzohairy 2011). MEGA 7 was used to select the best phylogenetic model, (Kumar & al. 2016). Bootstrap analysis was performed with 1000 replications. A Maximum Likelihood (ML) phylogenetic tree was generated using MEGA 7 with default settings (Kumar & al. 2016) under the K2 + G model (Nei & Kumar 2000).

Phylogenetic results

A megablast search of the GenBank nucleotide database using the nrITS (717–724 bp) Pakistani *Gerronema* sequences showed three *Gerronema nemorale* sequences from the Republic of Korea (EU883592–EU883594) with 99.5% similarity and a single sequence from China (LT716047) with 99.4% similarity. Complete alignment of the ITS region comprised 926 positions, including gaps. The analysis involved 42 nucleotide sequences. Models with the lowest BIC scores (Bayesian Information Criterion) were considered to best describe the substitution pattern. All positions containing gaps and missing

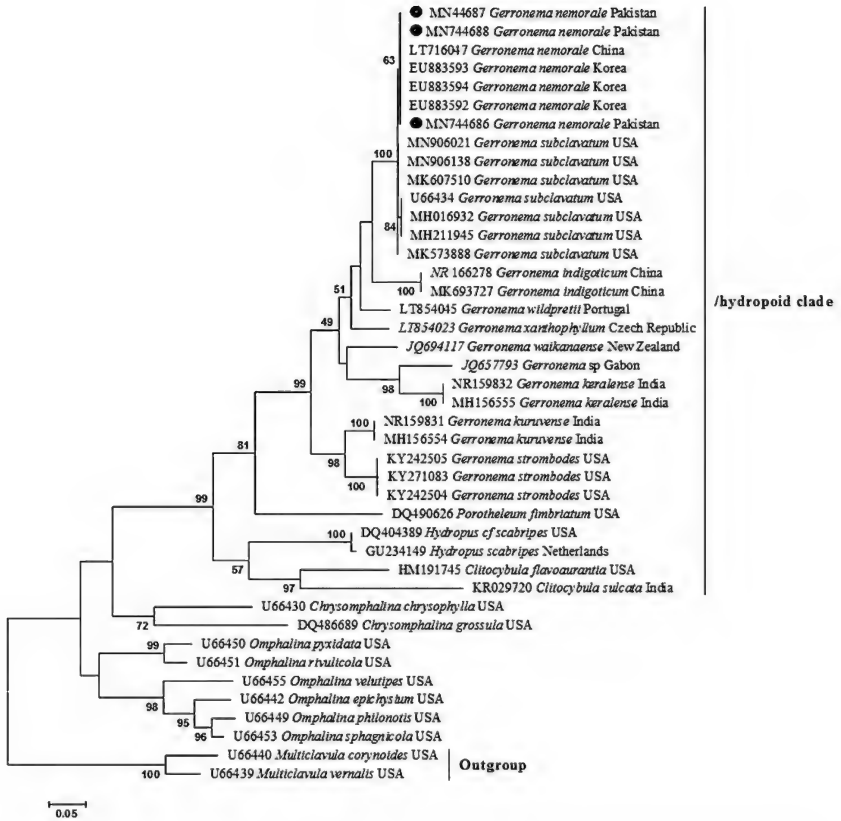

FIG. 1. Molecular phylogenetic analysis by Maximum Likelihood; nrITS sequence-based ML phylogram depicting the placement of *G. nemorale* within *Gerronema*. Values at nodes indicate bootstrap support. Scale bar indicates the number of substitutions per site. Newly generated sequences are marked with ●.

data were eliminated during model estimation. K2 + G Model showed the following base frequencies A (0.250), C (0.250), G (0.250), T (0.250) and a gamma distribution shape parameter of 0.35. The nucleotide substitution rates estimated according to this model were A/G = 0.178, A/T = 0.036, C/G = 0.036, C/T = 0.178, and G/T = 0.036.

The ITS phylogenetic tree (FIG. 1) generated from the ML analysis nested the sequences in the /hydropoid clade with 99% bootstrap support. All *Gerronema nemorale* sequences and our new Pakistani sequences clustered together with strong bootstrap support (99%).

Fig. 2. *Gerronema nemorale.*
Basidiomata: A. FA249 (MN744686); B. FA236 (MN44687); C. FA239 (MN744688).
Scale bars = 1 cm.

Taxonomy

Gerronema nemorale Har. Takah., Mycoscience 41(1): 16 (2000) Figs 2–3

Basidiomata solitary or grouped. Pileus 10–13 mm diam, convex with umbilicate centre, margin inflexed, uplifted and wavy on maturity, innately finely radially fibrillose to striate-rugulose except for the centre, yellow to brown when young (2.5Y6/8–7/8), finally dull yellow (2.5Y8/4). Lamellae arcuate-decurrent, subdistant, narrow, thin, pale yellow (2.5Y8/4); edges fimbriate, concolorous, finely pubescent. Context hollow in stipe, yellowish (2.5Y8/8) in pileus. Stipe 20–34 × 1–2 mm, cylindrical, broader at apex, subbulbous at base, straight, central or eccentric, slender, firm, hollow, olive

yellow to pale yellow (2.5Y6/8–8/4), scabrous all over. Spore print white. Odor and Taste not distinctive.

Basidiospores [60/8/3] (7.5–)8–9.7(–10) × (4.5–)5–5.9(–6) µm, avl × avw = 8.7 × 5.4 µm, Q = (1.50)1.60–1.64(–1.66), avQ = 1.6, ellipsoid to broadly ellipsoid, smooth, inamyloid, thin-walled, hyaline. Basidia 26–37 × 5–7.2 µm, clavate, with 4 sterigmata. Basidioles 25–34 × 5–7 µm, clavate or cylindrical. Cheilocystidia 26–51 × 4–9 µm, abundant, variable in shape (clavate, subcylindrical, subutriform, or subfusoid), smooth, colorless or with pale yellow contents, thin-walled. Pleurocystidia absent.

Pileitrama hyphae cylindrical, sarcodimitic (a dual hyphal system with two types of generative hyphae: wide vessel hyphae that are non-septate, fusoid, and thick-walled and narrow flexuous hyphae (sometimes called binding hyphae) that are thin-walled, sinuous, and branched. Pileipellis a cutis of thin-walled hyphae, 2–5 µm wide, cylindric, smooth, colorless or with pale yellow contents; terminal cells swollen (clavate), 2–9 µm wide, true pileocystidia not observed. Stipitipellis a cutis of parallel hyphae, 2–10 µm wide, cylindric, smooth, colorless or with pale yellow contents, thin- to thick-walled; Caulocystidia (terminal cells) 22–63 × 5–10 µm, irregular, cylindrical or clavate, often capitate, with contents yellowish in KOH; Stipititrama sarcodimitic (possessing a dual hyphal system composed of two types of generative hyphae) Clamp connections present in all tissues.

Specimens examined—**PAKISTAN**, **Punjab**, Murree Hills, 2290 m a.s.l. solitary to caespitose, on dead fallen twigs on forest floor in mixed forests of *Abies pindrow*, *Cedrus deodara*, *Pinus roxburghii*, *P. wallichiana*, *Quercus dilatata*, *Q. oblongata*, 14 August 2018, Fauzia Aqdus FA249 (LAH36351, GenBank MN744686); FA236 (LAH36370, GenBank MN44687); FA239 (LAH36372, GenBank MN744688).

Distribution—*Gerronema nemorale* has previously been recorded from Japan, Republic of Korea, and China.

Discussion

Gerronema nemorale was originally described from Japan (Takahashi 2000) and subsequently reported from Korea (Antonín & al. 2008); its presence in China is suggested by an unpublished sequence LT716047 in GenBank. Our collections are the first record of the species from South Asia and the first record of the genus from Pakistan.

The Pakistani basidiomata exhibit the omphalinoid appearance, decurrent lamellae, thin-walled smooth basidiospores, sarcodimitic tramal tissues, abundant cystidia on the stipe, and lignicolous habitat that led us to *Gerronema* (Singer 1970, 1986).

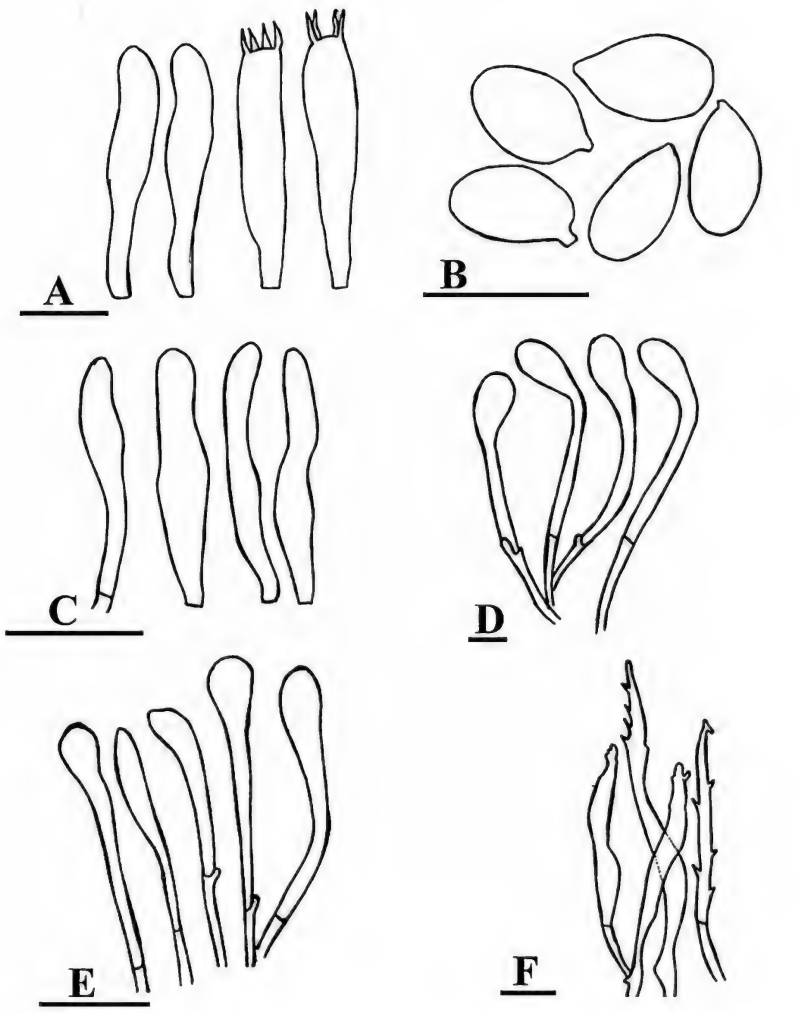

Fig. 3. *Gerronema nemorale* (FA249; MN744686):
A. Basidia and basidioles; B. Basidiospores; C. Cheilocystidia;
D. Pileipellis; E. Stipitipellis; F. Tramal hyphae. Scale bars = 10 μm.

Gerronema subclavatum (Peck) Singer ex Redhead (described by Bigelow 1970 as *Omphalina subclavata*) from North America resembles *G. nemorale* in its plano-convex pileus with a depressed center and incurved margin, fibrillose pileus surface, decurrent lamellae, smooth inamyloid ellipsoid and

similarly sized (6–10 × 4–5.5 µm) basidiospores, absence of pleurocystidia, and lignicolous habitat. However, *G. subclavatum* is distinguished by its broader (3–25 mm) pileus that is subhygrophanous, infundibuliform in age, and more dully colored (with olive to brownish olive hues); slightly fungoid, disagreeable, or bitter taste; larger (27–40 × 5.5–8.5(–10) µm) basidia that are rarely 2-spored; occasional cheilocystidia; very scattered habit; and versiform pileocystidia (Bigelow 1970). A pair-wise alignment comparing *G. nemorale* ITS sequences with *G. subclavatum* (MK607510) showed 99.2% similarity. Phylogenetic studies showed a close relationship between both taxa despite the morphological differences. We were unable to examine the type specimens, and more research needs to be done in the future to resolve this issue.

Gerronema strombodes (Berk. & Mont.) Singer (FJ596789) showed only 90.4% similarity with *G. nemorale* (FA249) in a BLASTn search using the ITS sequence (717 bp). A species originally described from USA (Singer 1961), *G. strombodes* is morphologically similar to *G. nemorale* in its fibrillose pileus with depressed center, subdistant lamellae, ellipsoid basidiospores, and absence of pleurocystidia and pileocystidia. However, *G. strombodes* is distinguished from the Pakistani collection by its larger basidiomata, grayish white pileus, longitudinally striped stipe that is slightly pruinose at the apex, 1–4-spored basidia, and absence of caulocystidia (Singer 1961). *Gerronema strombodes* was removed from *Chrysomphalina* and retained in *Gerronema* based on its sarcodimitic tissues; and the new combination *G. xanthophyllum* (Bres.) Norvell & al. was proposed for a vicariant European taxon that had been confused with *G. strombodes* (Norvell & al. 1994). The name *G. xanthophyllum* [≡ *Clitocybe xanthophylla* Bres., = *Omphalia hypoxantha* Bres.] was selected based on examination of original material that most closely matched the European concept to which *G. strombodes* had been misapplied (Norvell & al. 1994).

Gerronema waikanaense (G. Stev.) J.A. Cooper (Cooper 2014) was originally described by Stevenson (1963; as *Hygrophorus waikanaensis*). This species shares with *G. nemorale* decurrent lamellae, 4-spored basidia, inamyloid basidiospores, absence of pleurocystidia and pileocystidia, and cylindrical caulocystidia. However, *G. waikanaense* is distinguished by its broader (10–30 mm) basidiomata, the minutely fibrillose pileus surface, and absence of cheilocystidia (Cooper 2014). A pair-wise alignment comparing the ITS sequences of *G. nemorale* and *G. waikanaense* (JQ6941171) showed only 87.5% similarity.

Gerronema kuruvense K.P.D. Latha & Manim. described from Kerala State, India (Latha & al. 2018) resembles *G. nemorale* in its pileus with a depressed center, subdistant lamellae, a stipe with a subbulbous base, absence of pleurocystidia, and the presence of caulocystidia. However, *G. kuruvense* is distinguished by its slightly smaller (≤4–11 mm diam.) pileus that is hygrophanous, 2-spored basidia, absence of cheilocystidia, and the presence of true pileocystidia (Latha & al. 2018). A pair-wise alignment comparing the ITS sequences of *G. nemorale* and *G. kuruvense* (NR120035) showed only 87.1% similarity.

Gerronema indigoticum T. Bau & L.N. Liu described from Guangxi Province, China (Liu & al. 2019), resembles *G. nemorale* in its umbilicate pileus with an inflexed (eventually uplifted) margin that is innately finely radially fibrillose to striate, decurrent lamellae, a broadly based stipe, absence of pleurocystidia and true pileocystidia, and the presence of cheilocystidia and caulocystidia. However, *G. indigoticum* is distinguished by its blue to blue-green basidiomata and slightly larger (≤9–16 mm diam.) pileus, smaller (6.8–8.8 × 3.7–4.4 µm) basidiospores, 2–4-spored basidia, and smaller but broader cheilocystidia (20–27 × 8–12 µm; Liu & al. 2019).

Finally, *G. nemorale* somewhat resembles *G. wildpretii* Bañares & al. from Canary Islands, Spain (Bañares & al. 2006), in its similar umbilicate pileus, subdistant lamellae, stipe with a broadened base, absence of pleurocystidia, and presence of cheilocystidia. *Gerronema wildpretii* is distinguished by its larger (25–70 mm diam.) hygrophanous pileus, 1–3-spored (rarely 4-spored) basidia, and true pileocystidia, and absence of caulocystidia (Bañares & al. 2006).

BLASTn search results and the ITS-based phylogenetic analysis supports *G. nemorale* among the other species of *Gerronema*. Our ITS phylogeny nests the Pakistani sequences in the /hydropoid clade with 100% bootstrap support together with *Hydropus* s. str., *Clitocybula*, and *Porotheleum fimbriatum* (Moncalvo & al. 2002). All *G. nemorale* sequences clustered together with strong bootstrap support.

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Regional annotated mycobiota new to the Mycotaxon website

Abstract—Mycotaxon is pleased to add a new annotated species distribution list to our 143 previously posted free-access fungae. The 17-page "Lichenized *Ascomycota* on *Piptadenia moniliformis* and *Solanum mauritianum* in the Raso da Catarina Ecoregion, Caatinga, Brazil" by Rebeca Leite Barbosa & Nadja Santos Vitória may be downloaded from our website via http://www.mycotaxon.com/mycobiota/index.html

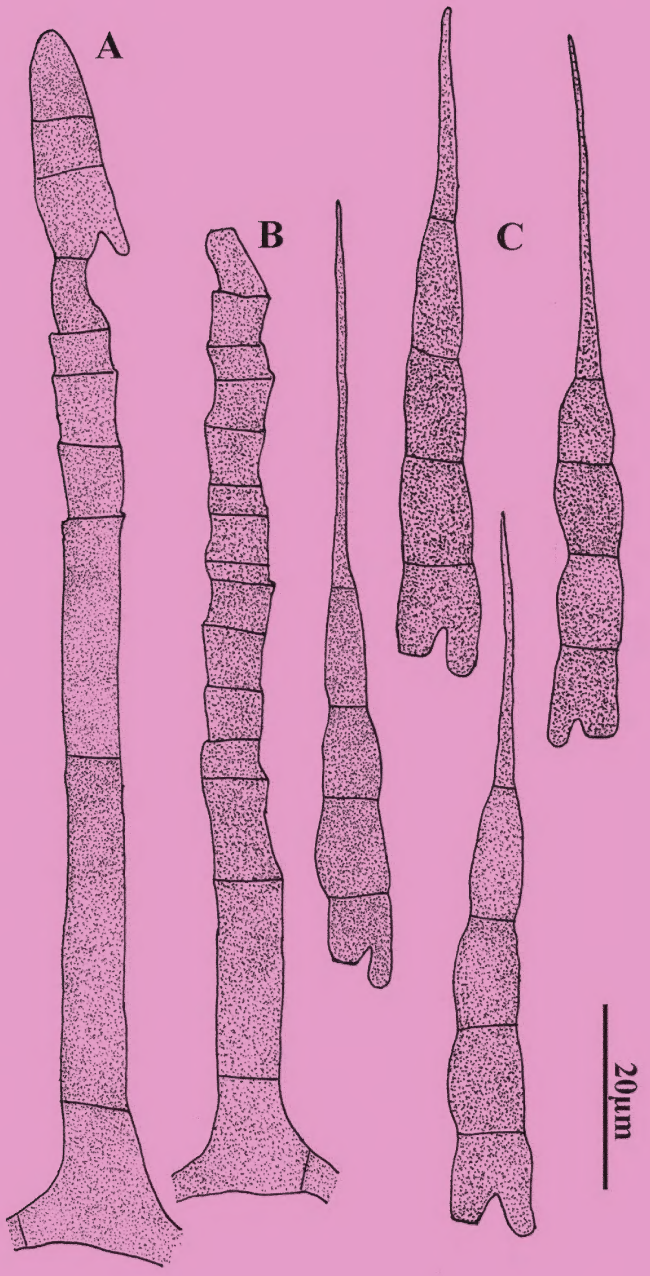
SOUTH AMERICA

Brazil

Rebeca Leite Barbosa & Nadja Santos Vitória. Lichenized *Ascomycota* on *Piptadenia moniliformis* and *Solanum mauritianum* in the Raso da Catarina Ecoregion, Caatinga, Brazil. 17 p.

Abstract—Our taxonomic survey of the lichenized *Ascomycota* associated with *Piptadenia moniliformis* ("quipembe") and *Solanum mauritianum* ("cassatinga") in the Raso da Catarina Ecoregion, Bahia State, Brazil was conducted in the village of Juá (municipality of Paulo Afonso) from July 2017 to April 2018. All specimens were analyzed in the Mycology Laboratory and are curated in the Didactic Collection, Fungal Herbarium, and Fungal Culture Collection (MICOLAB UNEB-VIII). We identified twenty-four lichenized fungal taxa representing 16 genera based on morphological characterizations and measurements of the fungal structures; of those, 16 had been collected on *P. moniliformis* and eight on *S. mauritianum*. Those plants are here described as new hosts for those fungi. Additionally, we report three new lichen records for Brazil and 13 for Bahia State.

Key words—biodiversity, lichenization, semiarid, taxonomy



Teratospermopsis protuberata sp. nov.
(Xu & al.— Fig. 1, p. 89)
Jian Ma, *artist*